ITS
America

Intelligent Vehicle Initiative Forum

Proceedings

Sponsored by
ITS America's
Safety and Human Factors Committee, and
Advanced Vehicle Control and Safety Systems Committee

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INTELLIGENT VEHICLE INITIATIVE (IVI) FORUM

INTRODUCTION

Purpose

This event, jointly sponsored by ITS America's Advanced Vehicle Control and Safety Systems (AVCSS) and Safety and Human Factors (S&HF) Committees, was designed to review and discuss the U.S. Department of Transportation's **Intelligent Vehicle Initiative** proposal. This two-day meeting reviewed the initiative's objectives, solicited stakeholder inputs, and identified areas of cooperation among government, industry, and the research community. The meeting also highlighted the Japanese Ministry of Transport's Advanced Safety Vehicle (ASV) development program.

Meeting Structure & Proceedings Contents

The IVI Forum consisted of the following elements: A review of the Japanese Advanced Safety Vehicle (ASV) program, Background Presentations by the U.S. DOT Administrations, Industry Panel Discussions, Breakout Group Sessions, Open Forum and Discussion of Issues

The proceedings are structured around these basic elements and contain

- Background Presentations
- Panel Discussion
- Breakout Group Summaries
- IVI Forum Discussion
- IVI Planning Group
- Meeting Attendees
- Meeting Agenda
- Attachments:
    - IVI Discussion Paper
    - IVI Issues Paper
    - Presentation Overheads

Summary

The forum produced a very animated discussion of the IVI program. Participants and attendees expressed a wide range of views on the IVI concept and contents. These views were diverse and frequently in conflict; no consensus was reached on any of the more important issues. However, the discussions were useful in that they produced many fresh ideas and insights and an uninhibited exchange of views from various public and private sector participants.

Acknowledgments

We would like to thank the co-chairs of this meeting; Bill Stevens as Chairman of the Advanced Vehicle Control and Safety Systems Committee, and Eugene Farber as Chairman of the Safety and Human Factors Committee. ITS America would like to thank the members of the meeting planning group (Dick Bishop, Mike Briggs, August Burgett, Gene Farber, Jack Ference, Tom Granda, John Hitz, Joe Koziol, Bret Michael, Jim Misener, Ray Resendes, Raghavan Srinivasan, and Bill Stevens) for their hard work and effort in forming the program. The Planning Group, ITS America's S&HF Committee, and AVCSS Committee would like to acknowledge the important contributions of the presenters, panel members, breakout session leaders, the U.S. DOT, ITS America staff, and others who contributed to the success of this meeting:

Presenters:

Joseph Kanianthra
George Ostensen
Ray Resendes
Denis Symes
Hiroshi Tsuda
Sadayuki Tsugawa

Panelists:

Hamed Benouar
Mike Briggs
Eugene Farber
Bjom Klingenberg
Thomas Lambert
John MacGowan
Ashok Ramaswamy
Steven Shladover
Samuel Tignor

Breakout Group Leaders:

Mike Briggs
Eugene Farber
Jim Misener
Bill Stevens

BACKGROUND PRESENTATIONS

1.0 Outline of Japanese Safety Programs

Mr. Hiroshi Tsuda (International Fellow, ITS America) overviewed ITS safety related activities in Japan, including the Advanced Safety Vehicle (ASV) program aimed toward developing a prototype vehicle for accident avoidance and mitigation of injuries and damage. During the second phase of the ASV program (1996-2000) six major safety technology fields will be emphasized: (1) preventative safety, (2) accident avoidance, (3) autonomous driving, (4) damage decreasing, (5) post-impact injury mitigation, and (6) fundamental automotive engineering technologies. Thirteen participating companies will be researching and developing 32 system technologies in these corresponding areas (e.g., vision enhancement systems, blind area monitoring/warning systems, drowsy driver systems, etc.). The goal of the program, sponsored by the Ministry of Transport, is to equip vehicles (buses and trucks as well as automobiles) with advanced technologies designed to improve vehicle safety. ASV will be integrated with AHS in the future. (Presentation overheads attached).

Dr. Sadayuki Tsugawa (Ministry of International Trade and Industry, MITI) briefed the group on a related vehicle-oriented Japanese project - the Super Smart Vehicle System (SSVS). Sponsored by MITI, the SSVS program promotes the application of AVCS technologies for the future. It attempts to harmonize safety, efficiency, and environmental concerns as well as incorporate the specific needs of an aging society into advanced vehicle transportation. Current research encompasses inter-vehicle communication, inter-vehicle gap measurement, and cooperative driving. (Presentation overheads attached).

2.0 Overview: DOT's Intelligent Vehicle Initiative

Mr. Ray Resendes (ITS JPO) outlined the Intelligent Vehicle Initiative - a research and development program for "accelerating the development, availability, and use of integrated systems that help drivers process information, make decisions, and operate more safely and effectively." The program plan covers the duration of NEXTEA, but its vision extends beyond. The IVI program is designed to improve the level of understanding of how emerging ITS vehicle-based technologies can be applied to improvements in safety and other of today's highway transportation problems and benefits that result. Safety is the highest priority within the initiative. The IVI program is unique in the following regard:

- Multi-agency coordinated effort within the U.S. DOT (FHWA, NHTSA, FTA, FRA) to coordinate vehicle-related ITS programs
- Emphasizes near-term safety benefits as a high priority issue
- Proactive program integration (single budget for vehicle-related ITS programs)

- Encompasses cars, buses and trucks
- Partnerships with industry, States, and other organizations
- Early field test evaluations with emphasis on assessing benefits, and associated demonstrations
- Technical Integration: Builds on current ITS development (NHTSA, FHWA, FTA, FRA)
- Accelerated system integration of human factors considerations
- Consistent with the National ITS Architecture

The program is centered around three levels of increasing capabilities and system integration starting with driver warning and information systems, driver assistance technologies, and automation systems. These 3 functional levels will be integrated into cars, trucks, buses (and specialty vehicles) as the technologies mature; each vehicle generation will represent increasing levels of functionality. Three IVI vehicle generations (or testbed sequences) were described, some combining levels of functionality.

The DOT will be seeking inputs from automotive manufacturers and suppliers, and the ITS community. Future work includes the development of an IVI implementation plan (FY 1998 - 2003), and a Business Plan for the National Science and Technology Council. (Presentation overheads attached).

3.0 National Highway Traffic Safety Administration (NHTSA) Report

Dr. Joseph Kanianthra (NHTSA) overviewed NHTSA's mission (to save lives, reduce injuries and reduce the economic burden caused by traffic accidents and deaths on U.S. highways) and discussed ongoing work to facilitate the identification and deployment of effective crash avoidance systems using emerging technologies. Current research projects target opportunities in three basic areas addressing specific collision types (rear-end, lane change and merge, intersection, etc.), driver performance (status monitoring, vision enhancement, etc.), and post-collision injury mitigation. Future objectives include improving our understanding of system capabilities, evaluating consumer acceptance, estimating real-world safety benefits, and facilitating deployment of crash avoidance systems by developing partnerships with product designers and the automotive industry.

Under the IVI program, NHTSA will seek to integrate intelligent systems into passenger vehicles, demonstrate system feasibility, and develop test procedures for systems and performance evaluation. Integration is expected to accelerate the introduction of intelligent systems, provide information on their desirability, reduce manufacturing and consumer costs, and improve marketability. Future activities will be geared towards completing development and research of collision avoidance systems, identifying and selecting systems for integration, developing an integration plan, and determining the real world effectiveness of these systems using simulation, test track experiments, and field operational tests.

NHTSA has conducted preliminary safety benefits analyses associated with several systems (Rear-end crash driver warning systems, lane-change merge aids, and road departure warning systems). If all vehicles were equipped with these three systems, it is estimated that over one million crashes on U.S. highways could be eliminated per year. Numerous challenges lie ahead before such systems can be deployed, including: accelerating market readiness, promoting standardization of performance, reducing system cost, increasing consumer acceptance, and generating market demand. (Presentation overheads attached).

4.0 Federal Highway Administration (FHWA) Report

Mr. George Ostensen (Federal Highway Administration) overviewed FHWA's ITS research program which encompasses the Automated Highway System (AHS), part of the Driver-Vehicle Interface for ITS (DVI), and Motor Carriers (CVO) program elements. Mr. Ostensen also discussed the relationships among these programs and IVI. For example, AHS and IVI both target a full range of vehicle control applications across vehicle platforms, involve some degree of cooperative system technologies (infrastructure-to-vehicle, vehicle-to-vehicle, etc.), and will rely on staged deployments. The DVI program is a collaborative effort involving FHWA, NHTSA, FTA, and OMC emphasizing human factors integration efforts. Key activities of the program include identification of human factors integration issues, knowledge gaps, and driver information delivery systems; this work is accomplished through integration experiments and studies using contract and in-house research resources. The Office of Motor Carriers realizes that commercial vehicle operations stand to benefit from truck safety systems and that this industry represents a potential "early winner" for IVI technologies. Several on-going projects (including drowsy driver research) were described. (Presentation overheads attached).

5.0 Federal Transit Administration (FTA) Report

Mr. Denis Symes (Federal Transit Administration) described opportunities to aid transit operators and travelers through emerging ITS technologies and the IVI program. Transit systems - currently equipped with mobile communications systems, centralized computers and dispatch centers - can be enhanced by IVI systems leading to increased safety, efficiency, and service. The FTA is developing IVI technologies to enhance both passenger and operator safety, efficiency, service, and overall system effectiveness. Key features of an "intelligent bus" were described including: fleet management and scheduling services, electronic fare payment, impaired driver monitoring and reporting systems, and automatic vehicle guidance to allow for precise maneuvering in docking areas, terminals, and maintenance yards. (Presentation overheads attached).

PANEL DISCUSSION

This section highlights industry perspectives voiced during a panel discussion. Panelists, representing various industry stakeholders (see below), were provided an opportunity to voice their opinions, comments and reactions to the new initiative.

Industry	Panel Members
Automotive:	*Mr. Eugene Farber, Ford Motor*
	Dr. Dennis Mike Briggs, General Motors
System Supplier:	*Mr. Ashok Ramaswamy, Delco*
CVO:	*Mr. Bjom Klingenberg, Surface Transportation Associates*
Transit:	*Mr. Thomas Lambert, Houston Metro*
Infrastructure:	*Mr. Hamed Benouar, CalTrans*
Research:	*Dr. Steven Shladover, UC Berkeley - California PATH*

Gene Farber (Ford Motor Company) welcomed the opportunity to advance the cause of automotive safety which he characterized as an appropriate public sector issue, but one which requires industry support. Mr. Farber also noted the following:

- IVI needs a near-term project focus (10 yrs or less).
- IVI should involve the automobile manufacturers as equal partners with the government (have equal say in what is done). The industry must be able to help define and shape the program if it is to succeed.
- IVI products must represent a value to customers.
- More discussion regarding program content and institutional arrangements are needed.
- IVI should be a technically focused program; the industry is not interested in developing demonstration vehicles, per se. Technical issues include: CAS sensor technology, sensor fusion, cooperative systems, human factors issues, standardization, field testing, etc.
- The maturity of current CAS technologies may be over-estimated.
- IVI should adopt a high level systems view that seeks the most efficient approaches to reducing motor vehicle crashes.
- DOT should consider broadening the scope of IVI to encompass crash worthiness as well as crash avoidance.
- IVI should identify plausible deployment scenarios for any non-autonomous solutions (an evolutionary path to deployment needs to exist).

Mike Briggs (General Motors) indicated that no formal GM position could be advanced until the IVI program becomes more well-defined. GM looks forward to working with the U.S. DOT to further define and guide the IVI program. Dr. Briggs offered the following personal comments:

- DOT should pursue a more aggressive time-line for Generation I light vehicles to include some limited vehicle intervention and control.
- Driver risk compensation needs to be addressed as part of the IVI plan.
- DOT should consider using the NAHSC model for addressing institutional and societal issues.
- A long-term IVI vision should be established with intermediate milestones.

Ashok Ramaswamy (Delco Electronics) reported that the near-term deployment focus of the IVI program is appropriate and that:

- Existing vehicles already have high levels of electronics (ABS, airbags, head-up displays, etc.). IVI should emphasize the integration of safety related systems.
- Driver warning , assistance, and vehicle automation is a good way of structuring the program goals.
- User acceptance will depend on system cost.
- IVI system capabilities can be increased (without substantial added cost) by using high levels of physical and functional integration.

Bjorn Klingenberg (Surface Transportation Associates) remarked that IVI is good news for the CVO industry given the potential safety benefits. He also noted the following:

- Economic outcomes will drive the success of IVI for the CVO industry; IVI promises a quick return in the investment.
- Fear of automation is a concern. Safety benefits of automation must be clearly identified, and systems carefully and gradually implemented.
- Specialty vehicles and CVO encompass a broad vehicle industry with a diverse set of needs which must be considered.
- The CVO industry is willing to share knowledge contributing to the advancement of IVI; the industry is already conducting infrastructure cooperative work.
- Fundamental differences between CVO and other vehicle industries need to be considered; commercial vehicle operators assume a different role than light passenger vehicle drivers. Changes in allocation of function (automation) will have impacts on Hours of Service rules, for example.

Tom Lambert (Houston Metro) recognized that this initiative is at its formative stage and that safety is its primary focus. Mr. Lambert was pleased to see that the program recognizes that safety and mobility are related. He also noted that:

- The National Automated Highway System Consortium provides an excellent model for bringing about public/private, private/private, and public/public partnerships.
- Incremental opportunities exist today to enhance transit operations (bus, rail, maintenance operations, etc.).
- The IVI program provides an opportunity to show the incremental benefits of this type of advanced technology.
- IVI technology should also be applied to Emergency Response Service vehicles (fire trucks, police cars, etc.).
- To demonstrate early winners, IVI technologies should be applied to transit and specialty vehicles. The transit environment is a great candidate for demonstrating enhancements in safety, mobility, and quality of life afforded by IVI technologies.
- Mayday systems should also be integrated into the IVI program.

Hamed Benouar (California DOT) noted that:

- Safety and congestion are both concerns. It is not clear how IVI addressed the long-term challenge of congestion. IVI needs to stress short-term safety benefits, but also focus on incremental deployments leading to long-term goals (like congestion relief).
- The focus of the program should be on developing system technologies rather than integrating systems.

Steve Shladover (U.C. Berkeley - California PATH) commented that:

- Cross-cutting activities (issues not specific to a vehicle type or system) do not appear to fall within the categories outlined in the IVI program. Initial IVI resources should be allocated to the development of an underlying knowledge base in areas such as human factors, sensor and communication technologies, benefits assessment, etc.
- Existing programs within the U.S. DOT are well defined; IVI's relationships to these must be made explicit.
- It is necessary to understand how individual safety systems operate independently first before integrating system capabilities. A program schedule that indicates appropriate integration time-lines needs to be developed; this should be driven by our level of understanding of the individual systems.
- The highway is an important component of the driving environment (as reflected in the original name "Intelligent Vehicle Highway Systems"). We need to remember that and outline the role of the highway within the IVI program.
- IVI may be seen as corporate welfare. In order to avoid this, the federal government should stimulate private sector industries to do things they would not otherwise do.

- IVI should not merely emphasize level 1 and 2 capabilities. The AHS demonstration showcased all three levels; IVI should build on this work.
- The current plan provides no sense of well defined deliverables (what are the measures of success?). These need to be defined in the context of existing programs.

Question and Answer Period: Summary

Q. The environment in Europe appears amenable to aggressively researching user acceptance issues. Does this climate exist in the U.S., and if so, how does it impact plans for IVI?

The Europeans appear more eager to introduce these radically new types of technologies than the U.S. which has a more litigious environment. However, field tests using ordinary drivers can and are being conducted in the U.S. Field testing is an extremely important tool for assessing user acceptance issues and should figure prominently in the IVI program.

Q. Is the financial component of the program attractive to the automobile industry (50/50 cost share and $25 million/year)?

Although some minimum funding level is necessary to continue progress in this area, the money is not the main attraction of IVI - a continuing and on-going dialogue with the government is more important. The specific funding ratio is not as important as the link to work within the vehicle industry. An 80/20 ratio may entice industry to work in areas in which they would not otherwise direct their resources.

Q. "If I was running the IVI program, here's what I'd want to see happen...."

- closer coordination between AHS and NHTSA as regards Crash Avoidance work, and FHWA and NHTSA human factors work.
- development of technology independent goals.
- completion of AHS specification as called for in the AHS program
- identification and prioritization of issues (from various stakeholders).
- cooperative undertakings to solve potential showstoppers (like limitations in existing technologies).
- implementation of a single CAS technology (like ACC) within the next 5 years.
- development of an architecture for AVCS/IVI

BREAKOUT GROUP SUMMARIES

An issues oriented breakout session was conducted addressing key issues and questions. Four breakout session groups were formed (led by Eugene Farber, Mike Briggs, Jim Misener, and Bill Stevens). This section contains the pool of breakout questions and presents the responses. For simplicity, breakout session responses were pooled. Note: because of time constraints not all of the questions were addressed by the groups. **Note: No consensus was reached on any of the more important issues. The responses below are intended to capture the flavor of the discussions and are not intended to serve as consensus recommendations.**

General

(1) *If you were to participate in the IVI program what current program elements/activities would you emphasize? What elements/activities would you remove or de-emphasize?*

Emphasize:

- Work on the underlying technology
- In-vehicle system architecture (debated)
- Infrastructure development and support
- Development of criteria for selecting among vehicle technologies
- Human Factors R&D
- Tool development (debated)
- Trucks, buses, specialty veh. (debated)

De-emphasize:

- Safety focus to the exclusion of efficiency
- In-vehicle system architecture (debated)
- Tool development (debated)
- Trucks, buses, specialty veh. (debated)

(2) *What would be your expectations, in terms of accomplishments toward advancing development and deployment, for an effort as broadly defined and as long-term as the IVI program?*

- Development of best standards and practices
- Identifiable roadmap of deployment paths
- Measurable reduction in fatalities and property damage
- Benefits which target high-risk driver groups
- Near-production test beds with evaluation methods and criteria
- Possible aftermarket Level 1 applications
- Human Factors research results available to all
- Radically improved working relationship between industry and government
- Deployable safety systems
- Cross-cutting, integrated technologies (no stove pipes)
- A short-term program implemented within the context of a long-term (15-20 yr.) vision

(3) *What new areas of research/development will be required to support the initiative ?*

- Understanding driver behavior, acceptance, risk compensation, response to nuisance alarms
- Human Factors
- System integration and Driver/Vehicle Integration Guidelines
- Benefits estimation
- Workload
- Infrastructure requirements
- Standards
- Predictive Tools

(4) *How do we ensure that this program produces substantive research rather than "show vehicles "?*

- Conduct deployment testing using a wide group of users
- Do not separate sensor and system-level issues
- Focus on the underlying technology (e.g., sensors)
- Demonstrate results of near-term current laboratory technology (target benefits to research/development
- Continue R&D testing for technology to meet long-term goals
- Share results among stakeholders
- Develop public/private partnerships to provide checks and balances

(5) *What are some critical technical issues that need to be addressed to hasten the deployment of advanced technology within the IVI program?*

- Path prediction
- Manhole covers vs. bumpers (need to develop obstacle sensing systems that can distinguish real targets from false targets)
- Driver risk compensation
- Extending existing field tests of Adaptive Cruise Control (ACC) to include ACC with automatic braking
- Machine perception
- Safety of software intensive systems
- Reliability/Cost
- Situation robustness
- Priority of systems to be included/integrated
- Fault detection/management
- Vehicle-to-vehicle communication
- System compatibility

Industry's Role

(6) *In what ways would industry prefer to interact with U.S. DOT to assess and advise on program direction as the IVI program progresses? What role can industry have in program management?*

(7) *How would the vehicle industry benefit from a successful IVI test?*

(8) *How does the IVI program fit into the motor vehicle industry's "develop, design, build, sell" paradigm?*

- Must offer industry members the opportunity to be safety/technology leader
- Industry goals and IVI program goals must be in concert

Government's Role

(9) *What will be the basis for determining which proposed IVI systems are funded?*

- Contribution to safety and efficiency
- How much deployment will be accelerated
- Technology feasibility
- Timeliness
- Realistic stage of deployment

(10) *What should the government definitely do/not do?*

Should NOT:

- Focus on short-range deployment
- Mention AHS
- Duplicate Advanced Safety Vehicle or Prometheus research

Should:

- Continue dialogue with industry on standards
- Focus on reasonable timeframe
- Emphasize modeling based real-world data
- Emphasize sensor fusion research

(11) *What Federal activities truly accelerate market introductions?*

- Enabling technology research rather than system research
- Sensor fusion research
- Making test beds and equipment more broadly available
- Continued analysis of crash databases

Infrastructure's Role

(12) *How important is the development and availability of infrastructure to the success of the IVI program? What degree of emphasis should it get?*

- Infrastructure enhances benefits (includes GPS, vehicle-to-road communications, and vehicle-to-vehicle communications)

(13) *What is infrastructure's role? What elements most need infrastructure to ensure success?*

- May vary with the specific application. Need to develop a systems context that identifies how infrastructure requirements change over IVI generations.

(14) *Is there a need for state and regional transportation authorities to be involved in the first generation of IVI? Is the concept of "radar-friendly" or "sensor-friendly" roadways important for the near-term systems?*

- Linkages with state and local government should be established now so they can provide inputs to 2nd and 3rd generation systems, and ensure their concerns are being addressed. (State DOT concerns include highways which are friendly to design, build, operate, and maintain)

System Integration

(15) *What is meant by "integration"? What are some potential definitions? What are some of the most challenging aspects of integration relative to IVI?*

(16) *Who decides what types and combination of systems should be integrated?*

- Ultimately the customer
- Next 5 years: objective measures, expert panels, the government, RFP for local applications

(17) *Should safety systems be integrated with non-safety systems?*

- Yes. Even though they might be labeled as “comfort and convenience” devices, all in-vehicle systems will relate to safety.

(18) *Who will provide overall technical direction and set technical requirements for integrated systems?*

(19) *To what extent will the industry cooperate and participate in integrating the systems?*

IVI FORUM DISCUSSION

This section summarizes discussions which took place as part of an open forum in which issues generated by the breakout groups, for example, were addressed. This forum also served as an opportunity to outline additional program guidance and advise to the U.S. DOT. A panel comprised of U.S. DOT representatives (NHTSA, FHWA, JPO, FTA) and industry stakeholders facilitated the process (see below). Key issues and responses are highlighted below.

Panel Members *(Bill Stevens, Moderator)*

Mr. Raymond Resendes, US. DOT - ITS JPO
Dr. Joeseph Kanianthra, NHTSA
Mr. Denis Symes, FTA
Dr. Samuel Tignor, FHWA
Mr. Johnathan MacGowan, FHWA
Mr. Bjorn Klingenberg, Surface Transportation Associates
Mr. Eugene Farber, Ford Motor Co.
Dr. Mike Briggs, GM
Mr. Jim Misenser, California PATH
Mr. Ashok Ramaswamy, Delco Electronics

Partnerships

- The IVI goals can only be achieved through industry partnerships. The National Highway Traffic Safety Administration does not want to mandate IVI system requirements by invoking the rule-making process. NHTSA seeks to accelerate the deployment of these technologies via partnerships (like the Collision Avoidance Metrics Partnership) with industry. Both government and industry stand to benefit from IVI.

- Collaborative agreements are the key to the success of the IVI program. A process needs to be developed to ensure that industry/government relationships work to achieve the IVI vision.

- The National Automated Highway System Consortium is a good partnership model in the sense that results are leveraged. The NAHSC would like to help DOT form their IVI program. It is important to retain the existing knowledge base provided by the NAHSC.

Pubic Interest

- Public interest in IVI technologies may accelerate deployment of these systems, thereby driving the cost down.

*Contracting **IVI** Work*

- The nature of the program will dictate the specific form the contracts will take.

Long-Term Goals

- Other industries plan long-term goals, why not the transportation industry?
  - IVI does have a long-term vision (as reflected in level 3 systems), but emphasizes near-term benefits.
  - A long-term context is essential and will help define the short-term goals.
  - Long-term goals need to be problem-oriented.
  - Long-term goals are only achieved through deployment which requires industry cooperation.

- Making AHS part of the long-term goal of IVI misses the real point of IVI which is safety oriented: IVI is intended to solve the safety problem, AHS is intended to solve the congestion problem. (Some noted that safety is a benefit of AHS)

Infrastructure

- IVI should take advantage of existing infrastructure components as well as identify future infrastructure needs.

- We need to identify where infrastructure investments will pay-off. Where and when is it appropriate to supplement vehicle-based systems with infrastructure components?

- Although cooperative system technologies can help solve some CAS problems by simplifying technical requirements, it also introduces a new level of complexity into the problem. Infrastructure components must be omni-present and require a dedicated stream of funding for their operation and maintenance.

- Some technical issues may not be realistically solved with out infrastructure support. A systems analysis view is needed which focuses on problems and identifies how best to solve them.

- A sufficient amount of road systems will need to be suitably equipped in order for cooperative infrastructure system to be cost effective; automobile manufacturers are unlikely to equip vehicles with the necessary systems otherwise. The aftermarket industry could play a role in this regard.

- Achieving infrastructure consistency (rather than cooperation, per se) is also a beneficial goal in itself.

Show Vehicles

- Show vehicles are OK and may be needed to excite consumer demand; however, they should present REAL systems and not showcase technologies designed to raise false expectations. Research vehicles could be available for demonstration.

- IVI should have functional demonstration vehicles as part of its outreach activities to communicate the vision and potential benefits to the public (and to secure funding).

- Functional demonstration products could also serve as testbeds; TravTek is a good example.

- Generation I vehicles should focus on near production testbeds. Methods and criteria for evaluation of these testbeds need to be developed.

- Prototype vehicles will be necessary since they often lead to new realizations and discoveries.

Proprietary Information

- Cooperative agreements can be structured so that “intellectual property” developed as part of a contract with the government is kept proprietary (remains with private industry). The CAMP effort is such a model.

Risk Compensation

- IVI vehicles need to have a mechanism in place that enables system performance to be tracked throughout deployment.

IVI FORUM PLANNING GROUP

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AGENDA
M Forum, August 5-6,1997
Marriott Mission Valley
Grand Ballroom (Salon D)

Tuesday, August 5

7:15 - 8:00 am	**Registration and Continental Breakfast**
8:00 - 8:30 **am**	**Welcome & Introductions** (meeting purpose, agenda, format) ***Mr. Eugene Farber, S&HF Committee Chairman*** ***Mr. William Stevens, A VCSS Committee Chairman***
8:30 - 10:15 **am**	**Background Presentations** (Mr. Eugene Farber)
8:30 - 9:15	<u>Outline of Japanese Safety Programs (Super Smart Vehicle System, Advanced Safety Vehicle, AHS</u>) ***Presenter: Mr. Hiroshi Tsuda, International Fellow ITS America***
9:15 - 10:15	<u>Overview: DOT's Intelligent Vehicle Initiative</u> ***Presenter: Mr. Raymond Resendes, DOT JPO***
10:15 - 10:30	**Refreshment Break**
10:30 - 12:00	**Report from DOT Administrations** Representatives from each administration will describe their mission, overview how IVI relates to current agency activities, and outline how they view their role within the new initiative.
10:30 - 10:50	<u>National Highway Traffic Safety Administration (NHTSA)</u> ***Presenter: Dr. Joseph Kanianthra, NHTSA***
10:50 - 11:20	<u>Federal Highway Administration (FHWA)</u> ***Presenter: Mr. George Ostensen, FHWA***
11:20 - 11:40	<u>Federal Transit Administration (FTA)</u> ***Presenter: Mr. Denis Symes, FTA***
11:40 - 12:00	Question &Answer Period
12:00 - 1:30 pm	**Lunch**

1:30 - 3:00 pm **Panel Discussion: Industry Perspectives** (Mr. William Stevens)

Perspectives and reactions from the various industry stakeholders. Panelists will be provided an opportunity to voice their opinions, comments, and reactions to the new initiative.

Automotive:	***Mr. Eugene Farber, Ford Motor***
	Dr. Dennis Mike Briggs, General Motors
System Supplier:	***Mr. Ashok Ramaswamy, Delco (invited)***
cvo:	***Mr. Bjorn Klingenberg, Surface Transportation Associates***
Transit:	***Mr. Thomas Lambert, Houston Metro***
Infrastructure:	***Mr. Hamed Benouar, CalTrans***
Research:	***Dr. Steven Shladover, UC Berkeley - California PATH***

3:00 - 3:15 pm **Refreshment Break**

3:15 - 5:30 pm **Breakout Groups**

Groups will be asked to consider and respond to a set of key issues & questions.

3:15 - 3:30 pm Assignment & Charge to Breakout Groups

3:30 - 5:30 pm Breakout Group Sessions

Moderators	Group and Room Assignments
Mr. Eugene Farber	Group A, Suite 307
Dr. Mike Briggs	Group B, Suite 3 17
Mr. Jim Misener	Group C, Grand Ballroom, Salon D
Mr. Bill Stevens	Group D, Grand Ballroom, Salon D

5:30 pm **Adjourn** (each group adjourns individually)

Wednesday, August 6

7:30 - 8:00 am **Continental Breakfast** (Grand Ballroom, Salon D)

8:00 - 11:00 am **Breakout Group Reports & Open Discussion**

In addition to the breakout group reports, this time will also serve as an opportunity to discuss issues generated by the breakout groups, and outline additional program guidance and advise to the U.S. DOT. This will be an open forum.

10: 15 - 10:30 Refreshment Break (rolling)

11: 00 - 12:00 **Review and Summary**

12:00 noon **Adjourn**

INTELLIGENT VEHICLE PROGRAM
DISCUSSION PAPER

1. Executive Summary

This document is intended to provide you with background infornnation to assist in the discussion of the Intelligent Vehicle Program. The policies stated have not yet been adopted by USDOT.

The opportunity exists to dramatically reduce the number of motor vehicle crashes which exact high penalties in fatalities, injuries, and economic costs for resulting emergency and health care, property damage, and highway congestion- The NHTSA estimates that the financial burden of these crashes exceeds $150 billion per year. USDOT and the automotive industry have been developing technology which assists drivers in avoiding crashes and operate more efficiently. Early versions of these systems are already commercially available (Eaton-Vorad for trucks and buses in U.S. and Mitsubishi ICC in Japan) and the potential of full and partial automation through vehicle-infrastructure cooperation has been demonstrated by the National Automotive Highway System Consortium. NHTSA estimates that with just three of these systems (rear-end, lane change/merge and roadway departure) fully deployed in the passenger car fleet, we could reduce the number of crashes by 17 percent.

In order to achieve these impressive goals, several technical, human centered and institutional issues must be overcome. During the period covered by ISTEA, the Department developed an extensive knowledge base in collision avoidance, automated highways and driver-vehicle interface. Reflecting on this progress, the Department has resolved to focus the ITS Vehicle programs into the Human-Centered *Intelligent Vehicle Initiative* in order to achieve the maximum public benefit in the shortest time. The Department will conduct the Intelligent Vehicle Program in cooperation with the automotive industry and other stakeholders. We will continue to improve our understanding of the causes of crashes, the potential for reducing these crashes and increase efficiency through the application of advanced vehicle based and infrastructure cooperative technologies and to encourage deployment of these systems. To achieve the program goals the Department will conduct research to increase the understanding of systems capability for the various levels of driver assistance products which complement the human driver's ability and perceptions.

In regard to Intelligent Vehicle program, the Department will fulfill its mission by facilitating the development, deployment and evaluation of safety and mobility enhancing products and systems. Among other things, this involves research into the science of crash avoidance and automated vehicle control to enable the development of these products. The department will develop performance guidelines-and specifications, evaluate the performance of such systems, and work with industry to demonstrate the most promising configurations to facilitate their deployment in the marketplace. These activities will be accomplished through the combined efforts of the

Department's operating administrations, the automotive industry, and other stakeholders working together under cooperative programs and partnerships that the Department sponsors.

We structured the Intelligent Vehicle program to address in three levels of capability. Each successive level has more advanced capability and sophistication over its predecessor. The first level system will provide warning and information services. The second level systems will provide limited driver assistance and the third level will provide automation.

During the program, the Department and our partners will configure successive generations of vehicles with increasing levels of capability. During the period covered by NEXTEA, we expect to make available a first generation passenger vehicle, heavy truck, transit bus and specialty vehicle. Each of the first generation vehicle types will have different levels of capability. The passenger vehicle is expected to have level 1 (warning and information) capabilities. The heavy truck, transit bus and specialty vehicle will have level 1 and some level 2 (driver assistance) capabilities.

Specific activities will continue from the Intelligent Vehicle's predecessor programs which directly support the program's goals. New activities will be initiated to address the specific problems related to achieving the program outcome. We will continue to expand the knowledge base for collision causation, driver behavior, driver acceptance and vehicle performance. We will continue to develop technologies which can reliably interpret the surrounding road environment (obstacles, other vehicles, low traction), facilitating a range of driver assistance systems. We will use this information to target technology development to achieve required capabilities. This will be translated into performance specifications for both system capability and the driver-vehicle interface. Integrated testbeds, for use in operational tests, will be built to validate the performance specifications and evaluate benefits and user acceptance. An architecture will be developed for in-vehicle functions and to integrate cooperative systems with the National ITS Architecture. Voluntary standards will be developed. And outreach and education activities will be conducted to coordinate with the various stakeholders. These specific activities will be detailed in the Intelligent Vehicle program plan which will be published in late 1997.

2. Introduction

The opportunity exists to dramatically reduce the number of motor vehicle crashes which exact high penalties in fatalities, injuries, and economic costs for resulting emergency and health care, property damage, and highway congestion. The NHTSA estimates that the financial burden of these crashes exceeds $150 billion per year. USDOT and the automotive industry have been developing technology which assists drivers in avoiding crashes and operate more efficiently. Early versions of these systems are already commercially available (Eaton-Vorad for trucks and busses in U.S. and Mitsubishi ICC in Japan) and the-potential of full and partial automation through vehicle-infrastructure cooperation has been demonstrated by the National Automotive Highway System Consortium. NHTSA estimates that with just three of these systems (rear-end, lane change/merge and roadway departure) fully deployed in the passenger car fleet, we could reduce the number of traffic fatalities by 17 percent.

Achieving these impressive goals is potentially hindered by a paradox.. This paradox postulates that a safety system could have a net effect of reducing safety if it resulted in more aggressive driving behavior or increased the complexity of the driving task. Recent experience with vehicle based safety systems (ABS) have not delivered the anticipated benefits.

During the period covered by ISTEA, the Department developed an extensive knowledge base in collision avoidance, automated highways and driver-vehicle interface. Reflecting on this progress, the Department has resolved to achieve the maximum public benefit in the shortest time requires focusing the ITS Vehicle activities into the Human-Centered *Intelligent Vehicle Initiative.*
The Department will conduct the Intelligent Vehicle Program in cooperation with the automotive industry and other stakeholders. We will continue to improve our understanding of the causes of crashes, the potential for reducing these crashes and increasing efficiency through the application of advanced vehicle based and infrastructure cooperative technologies and to encourage deployment of these systems. To achieve the program goals the Department will conduct research to increase the understanding of systems capability for the various levels of driver assistance products which complement the human driver's ability and perceptions.

3. Vision

The Vision statement describes a future that management envisions. It provides a description of what America will be like when the Intelligent Vehicle program is fulfilled.

In the Department's vision of the future driver-vehicle-highway environment, a wide variety of innovations will appear within and outside the motor vehicle to supplement the driver's efforts at vigilance and control. The Department will work cooperatively with the automotive industry and other stakeholders to plan for and facilitate the incremental deployment of Intelligent Vehicle Systems. Initially manufacturers will sell passenger vehicles with autonomous safety and information systems. These on-vehicle systems will evolve along a path from providing warning and information to actual driver assistance and intervention and finally the long term automation of the driving function. Concurrent and integral to the evolution of capability is the evolution from autonomous systems to vehicle to vehicle and vehicle to infrastructure cooperative systems. The Department will take the lead on the technical development and facilitating the deployment of Intelligent Vehicle in&structure.

Concurrent to the passenger car activities will be initiatives to develop and deploy First generation Heavy Vehicles, Transit busses and specialty vehicles. The capabilities of these vehicle will be keyed to their unique applications and highly trained drivers. Although safety is still the primary goal these vehicles will experience benefits in efficiency and mobility as well. Transit busses and specialty vehicles such as snow plows will use cooperative infrastructure systems to maintain longitudinal and lateral control. For-transit applications this-w-ill permit higher efficiency during peak periods of usage. For snow plows this will increase safety and efficiency by expediting operations during extreme inclement weather.

4. Mission

The Mission describes the organization's purpose or changes that the organization intends to directly effect.

The mission of USDOT with regard to the Intelligent Vehicle Program is to provide leadership, expertise, resources, and information to continually improve the quality of our Nation's highway system and the vehicle which operate on it. We undertake this mission in cooperation with all our partners to reduce traffic crashes and resulting injuries and fatalities. Our activities will also address the ancillary goals of enhancing mobility by improving public access to activities, goods and services and productivity by improving the economic efficiency.

In regard to the Intelligent Vehicle program, the Department will fulfill its mission by *facilitating the* development, deployment and evaluation of safety and mobility enhancing products and systems. Among other things, this involves research into the science of crash avoidance and automated vehicle control to enable the development of these products. The department will develop performance guidelines and specifications, evaluate the performance of such systems, and work with industry to demonstrate the most promising configurations to facilitate their deployment in the marketplace. These activities will be accomplished through the combined efforts of the Department's modal administrations, the automotive industry, and other stakeholders working together under cooperative programs and partnerships that are sponsored by the Department.

5. Background

Planning for the Intelligent Vehicle program must be conducted with the full recognition of the technical and societal issues which will impact the program. The motivation for government and industrial participation will shape the final program structure.

5.1 The Industrial Context

The primary industrial context that is at issue across the spectrum of near-term Intelligent Vehicle functionalities concerns the automotive industry. Although other industrial segments will no doubt contribute to the provision of products and services especially in connection with a cooperative infrastructure, the role of such companies in near-term Intelligent Vehicle products is not so crucial as is that of automakers and their suppliers. Nevertheless, a few will be cited below. The following observations serve to sketch the industrial context:

a) all industrial players will make their decisions for Intelligent Vehicle participation primarily on commercial terms.
b) the commercial case for Intelligent Vehicle participation must make sense in terms of the operational practices of the company and the realities that currently govern the way they partner with others to

acquire new technology, procure from their vendors, utilize their capital plant and labor pool, and market to their customers.

c) "near-term" Intelligent Vehicle products must be seen as feasibly marketed within 10 years, at most, in order to attract participation by the auto industry.

d) on the matter of automotive judgements, three additional observations are important, namely,

1) the judgements of Original Equipment Manufacturers (OEMS, or makers of finished vehicles) are not the same as those of suppliers furnishing automotive components or subsystems to the OEM'S.

2) the overcoming of negative OEM judgements requires hands-on evidence obtained with fully operating prototypes and confirmations that vendors can, indeed, supply the products as required.

3) supplier judgements about product readiness also hinge to some degree upon how their envisioned products are to be integrated into specific vehicles. Without a standard in-vehicle architecture, a multitude of differing communications interfaces must be satisfied if a supplier is to deliver to many platforms in the light vehicle market.

e) a great deal of component and system-level prototyping of driver assistance systems has already occurred within industry, albeit more heavily among overseas manufacturers than domestically. Thus, it is a strategy of the Intelligent Vehicle program to target those functionalities for which preceding industry investment has already prepared the basis for working prototypes.

f) "integration" in the sense of combining multiple driver assistance functions within individual vehicles for the sake of studying synergies and conflicts is not known to have occupied much attention from the automakers, to date. In this regard, the Intelligent Vehicle program is charting important territory that does not appear to have been yet given the consideration it will eventually need by industry.

g) it appears to be generally true that the automotive industry will only offer products for sale which depends upon a cooperative infrastructure after infrastructure has been deployed.

h) another enabling technology that begs the industrial context for an Intelligent Vehicle program is that of map databases which are augmented with station-by-station data on highway geometries. That is, the performance of certain driver assistance aids such as lane-keeping, road departure prevention, in-lane collision warning and avoidance, and others could be markedly improved, in principle, from an integrated database describing the immediate and upcoming radius, super-elevation and, perhaps, grade of the roadway. The industrial issue is, could the large investment for the development of such a database be financed through private capital, only?

5.2 The federal interest in ensuring public benefit from such systems

Federal involvements are traced to the missions of respective DOT agencies for improving safety, traffic efficiencies, fuel economy, air quality, etc. The underlying proposition is that a public Intelligent Vehicle program will move up the timetable upon which publicly-beneficial innovations will come into common use.

Aside from the question of accelerating the introduction of driver assistance products, there is an underlying assumption that industry may not be relied upon to maximize the public-benefit attributes of the products. Rather, industry may have the view that marketability is determined primarily by the market for comfort and convenience features of certain products. For example, decisions on development of intelligent cruise control are being made on the basis of convenience rather than safety improvement. There is also public sector concern to determine the traffic flow impacts of Iintelligent Cruise Control, but no publicly available industrial study of this issue is likely.

On the one hand, the federal participants could take the view that the Intelligent Vehicle program should insist on maximum public benefit from each candidate function- On the other hand, an overemphasis in this direction could very well discourage industrial interest if it appeared to divert too far from a truly marketable balance. Recognizing the need for balance, the federal role must still ensure that reasonably-achievable public benefits are identified. Further, the associated features to attain such benefits must be prototyped and demonstrated as packages that appear to be eventually marketable.

Other imperatives of the federal context for the near-term Intelligent Vehicle systems include the issues of cooperative infrastructure, federal motor vehicle safety standards, and broad concerns with the national economy:

Issues of cooperative infrastructure

Pertaining to the issues surrounding the order of deployment for infrastructure cooperation versus vehicle products that could use infrastructure cooperation is the issue of minimal autonomy for vehicles. That is, vehicle products that have minimal functionality to assure safety benefits that do not depend upon infrastructure cooperation could be the primary emphasis of a research program. Then, predicated on total life cycle cost analysis for deployment, operation and maintenance, systems could be developed that would enhance the minimal functionality, be they for autonomous vehicle operation or for cooperative infrastructure. Thus, transitional systems could be developed that present a platform that is expandable, scalable, and interoperable. Features could be added, perhaps even after market, to take advantage of cooperative infrastructure or enhanced autonomous features.

Standards

The program is constructed in such a way that it will provide research support for a variety of standards activity. Standards may be either voluntary, such as SAE and IEEE standards, or mandatory regulations, such as FCC Final Orders (for example, Final Order No. 95-499 which established frequency spectrum allocations and other performance requirements for vehicular radar sensors) or NHTSA Federal Motor Vehicle Safety Standards. Research that supports development of standards for a specific element of a system will be done with the realization that ultimately it is the entire system that provides the functionality or service. For example, standards for the driver vehicle interface will depend on the sensing capability and warning algorithms of a system. The criteria that must be met by each FMVSS are also a basis for organizing research -to -support all types of standards development These criteria: (1) be objective; (2) be practicable, and (3) meet a need for motor vehicle safety, will be used to identify research that will lead to standards, either voluntary or regulatory, that meet these criteria.

Matters associated with international competitiveness

Because the federal administrative role in any Governmental program is ultimately accountable to Congress, the industrial and social impacts of the activity may well be perceived in light of political themes. Accordingly, for example, it is likely that the impact of Intelligent Vehicle participation on the international competitiveness of firms will be an issue of some concern. In this regard, it seems likely that some foreign-based companies will be able to offer either more advanced technology, more experience in near-term driver assistance applications, and/or more enthusiasm for collaboration than some domestic counterparts. Such a development should be anticipated in the setting of policy on Intelligent Vehicle participation, balancing off the desire to accelerate the launch of publicly-beneficial products against the national concerns that trace ultimately to domestic employment and the health of a major domestic industry.

5.3 The challenge posed by modern driver assistance functions.

As the Intelligent Vehicle program undertakes to address a broad array of driver assistance systems, we should be generally aware that the tack upon which we are sailing is into truly uncharted waters. The basic question is, “how hard will it be to get each of the various system concepts into a truly market worthy stage of development? Scaled against the perspective of the 100 year history of the motor vehicle, it seems fair to suggest that technological assistance in the driving process, itself, will be a profoundly challenging stage of automotive advancement. After all, we’re designing a technology to fit the perception, cognition, and behavior of virtually the entire citizenry, in an everyday-safety-critical function.

To capture a major element of the human factors issue, consider the domain that has been addressed through motor vehicle technology up to the present time. If we reflect on the earliest motor cars, automotive technology confined itself to the attainment of mobility, only. Provisions for braking, steering, suspension, seating, lighting, glazing, and covering from the weather were crude, if present at all. Gradually, however, the motor vehicle became a more and more civilized machine, continuously improving in riding comfort, ergonomic adjustment, crash survivability, entertainment systems, climate control, etc. The quality of subsystems by which the driver controlled speed and path also steadily improved so that long-distance driving tended to become less and less of a chore.

But, throughout this epoch, no aspect of automotive technology ever tried to accomplish what the human driver does with his/her eyes in terms of assessing the immediate need for speed and path control Rather, the remarkable capabilities in human visual performance and the higher cognitive faculties by which risk-taking is judged and adaptation occurs surely explain a great deal about the success of the motor vehicle, under human control-. Thus it is-a bold proposition that automotive- technology would soon begin to complement the functional space previously occupied only by human perceptions and cognitive capability. Doing it on a simultaneous, “co-pilot;’ sort of basis such as envisioned in near-term

Intelligent Vehicle systems makes the user compatibility goals even more challenging, but presumably the overall system more robust.

6. Values

The Values describe things that are important to an organization that will impact how the Vision and Mission are fulfilled, and yet may not be directly addressed in their statements. These are the underlying principles of the organization.

Equity--The improvements made via this program will be distributed in a fair and non-discriminatory manner;

Decision making--Balanced and appropriate decisions should be made reflecting the issues and concerns of those impacted and considering all feasible alternatives (their costs, benefits, and outcomes). The Intelligent Vehicle program will be cooperatively managed by the modal administrations of USDOT with coordination by the ITS Joint Program Office.

Collaboration--Achieving the vision requires many people from a variety of disciplines and organizations to work together. This value is at the heart of the Intelligent Vehicle program whose mission will be achieved by USDOT in cooperation with the appropriate industry and stakeholders.

Leadership--USDOT is a strong and enthusiastic proponent of the Intelligent Vehicle program and the cooperative agreements entered into under the program..

7. Goals and Strategic Objectives

The Goals describe the general results or outcomes the organization intends to achieve. They can be described by measurable descriptors but usually can not be directly measured. For each goal, strategic objectives are defined. Strategic Objectives are written statements that describe an intended outcome. Strategic Objectives clearly describe measurable targets of achievement.

As opposed to the abstract nature of the vision and mission, the goals and strategic objectives are definable in real and measurable terms. The six characteristics of Strategic Objectives include: (I) An external focus, (2) measurable, (3) achievable, (4) clear, (5) comprehensive, and (6) supporting the mission and goal statements. Strategic objectives can also be defined for both outputs of the program and outcomes of the program. Outputs are the services and products that the program provides.

7.1 **Goals** - The primary and ancillary goals of the Intelligent Vehicle program mirror those of USDOT:

Primary Goal

Safety: Reduce highway crashes and resulting injuries and fatalities.

Ancillary Goals

Mobility: Improve public access to activities, goods and services.

Efficiency: Improve the utilization of the existing tranpsotation infrastrucure.

Productivity Improve the economic efficiency of the Nation's transportation system.

7.2 **Strategic Objectives** - The agency strategic objective is to achieve the deployment of Intelligent Vehicle systems for passenger vehicles, heavy trucks, transit buses and specialty vehicles.

7.3 Outcome Goal - Achievement of the goals of this program can be measured by:

1. the percentage of new vehicles sold or equipped with Intelligent Vehicle systems.
2. the percentage of the nation's highways equipped with the necessary Intelligent Vehicle infrastructure.

7.4 Output Goal - (result of activities within the programs span of control)

a. System Capability: Achieve full understanding of system capability for both vehicle based and infrastructure cooperative systems. This is expressed as objective test procedures and criteria for system performance for all pertinent driving situations, those requiring warning, intervention and those for which a warning should not be issued.

b. Driver-Vehicle Interface: Realizing the benefits of Intelligent Vehicle systems will ultimately depend on the effectiveness and acceptability of the flow of useful information between the driver and the vehicle. In order to achieve safe, useable and acceptable Intelligent Vehicles systems requires a full understanding of driver behavior, performance capabilities, and preference related to the design and functioning of the driver-vehicle interface.

c. User Acceptance: For each problem area, research will be conducted to gain a better understanding of the user acceptance of the proposed collision avoidance system. These projects will include consideration of the effects of measures of performance such as false positives, false negatives, nuisance warnings, perceived non-warnings, driver workload, factors affecting performance such as driver demographics, and cost. Initial studies will take the form of focus group discussions and questionnaires.

The level of understanding regarding driver acceptance will increase as projects proceed from conceptual systems, studied with the aid of simulation and computer analysis, to prototypes and test vehicles, and finally to operational tests involving a large number of drivers, vehicles, and operational conditions. Until a substantial sampling of drivers can be exposed to and can evaluate the performance of prototype or pre-production systems under realistic roadway environments, the state of knowledge regarding user- acceptance -will remain only at the "rudimentary" or "improved" level.

d. Benefits: The effectivness of safety and mobility systems will be based on baseline data and countermeasure performance data from simulators, test track, and operational tests. Includes consideration of user acceptance effects, risk compensation, confidence bounds on statistical data elements, and changes in severity of collisions that are anticipated .

8. Strategy/Initiative

A Strategy is an approach, or an implementation methodology that will lead to achieving the program outcome. It includes a description of how the goals and objectives are to be achieved, including a description of the operational processes, skills and technology, and the human, capital, information, and other resources required to meet those goals and objectives.

8.1 Strategy

The Intelligent Vehicle program is structured to address three levels of capability. Each successive level has more advanced capability and sophistication over its predecessor. The first level system will provide warning and information services. The second level systems will provide driver assistance and the third level will provide automation.

As the enabling research reaches maturity, they will be integrated into a series of testbeds. These products will include technology (e.g.rear-end collision warning system) as well as performance guidelines (e.g. driver-vehicle interface). The purpose for the integrated testbeds is to evaluate the additive effects of the technology and system performance and consumer acceptance as well as to validate the benefits estimates. Over the course of the program, succesive generations of the testbeds with increasing levels of capability will be developed. During the period covered by NEXTEA, we expect to produce a first generation passengar vehicle, heavy truck, transit bus and specilaty vehicle. Each of the first generation vehicle types will have different levels of capability. The passengar vehicle is expected to have level 1 (warning and information) capabilities. The heavy truck, transit bus and specialty vehicle will have level 1 and some level 2 (driver assistance) capabilities. Specific testbeds may have some vehicle-vehicle or vehicle-infrastructure cooperative capabilites. In these situations, the program will develop the infrastrucure component and provide for a means of evaluating it in real world situations. Table 1 lists the elements which must be better understood at each level of capability in order to achieve the program goals.

Table 1. Common Descriptors	
System Capability	Sensor Computational Driver Interface Infrastructure
Human Factors	User Acceptance Driver Vehicle Interface Alarm Accuracy Workload Risk Compensation
Architecture/Standards	Data Flows Compatibilities
Communication Systems	Short Range Fleet
Benefits	Reduced # Collisions Reduced Severity of Collisions Reduced Congestion

8.2 Initiatives/Activities

Specific activites will continue from the Intelligent Vehicle's predecessor programs which directly support the program's goals. New activites will be intiated to address the specific problems related to achieving the program outcome. We will continue to expand the knowledge base for collision causation, driver behavior, driver acceptance and performance. We will use this information to target technology development to achieve required capabilites. This will be translated into performance specifications for both system capability and the driver-vehicle interface. Integrated testbeds will be built to validate the performance specifications and evaluate benefits and user accpetance. An architecture will be developed for in-vehicle functions and to integrate cooperative systems with the National ITS Architecture. Voluntary standards will be developed. And outreach and education activities will be conducted to coordinate witht the various stakeholders Activities which we expect to conduct during the period covered by NEXTEA are described in Table 2. These specific activites will be detailed in the Intelligent Vehicle program plan which will be published in late 1997.

9. Program Funding

The administration's NEXTEA proposal requests a minimum $25 million annually to fund the Intelligent Vehicle program from contract authority. The Department expectsthat total funding will be at or near the FY1998 budget request. There will be a mix of fully funded government sponsored research as well as collaboration with industry and other stakeholders under cooperative agreements. The cooperative agreements will require a minimum cost share ranging from 20% to 50%.

10. Program Delivery

The Intelligent Vehicle program will be jointly managed by FHWA, FTA and NHTSA. These operating adminsitrations will jointly consider policy, technical, program direction and coordiantion issues facing the Intelligent Vehicle program. The ITS Joint Program Office will be responsible for coordination and budget oversight.

A mechanism will be provided for our partners and stakeholders to impact program direction. This may include an advisory board, a loaned executive program, public meetings and requests for comment.

11. Next Steps

The following near term activites are focused on developing the Intelligent Vehicle program plan in collaboration with the automotive industry and other stakeholders:

Planning Outreach - These activites are intended to seek policy and technical advice from potential Intelligent Vehicle program partners for the overall Intelligent Vehicle program direction.

Request For Information - A notice will be published in the Federal Register in late August 1997

Coordinate with industry - USDOT personnel will meet with automtive industry executives to discuss program direction.

ITS America Committees - A meeting of the techncial committees will provide a forum to exchange information between USDOT and Stakeholders on August 5 and 6,1997.

Industry Workshop - A dedicated workshop of stakeholder experts will be held in the Fall 1997 after the draft Intelligent Vehicle program plan is completed.

The Program Plan/Roadmap A draft program plan will be completed by October 1, 1997 following extensive discussions with stakeholders. It will be available for public review and comment.

Table 2. Abbreviated "High-level" IVI Matrix -- Program Activities for Generation.

	General	Light Vehicle	Heavy Vehicle	Transit Bus	Special Vehicle
In-vehicle and infrastructure technology	-Develop and validate performance specifications for integrated systems. -Define, develop, and test component systems as necessary.	-Collision avoidance warning; -Driver information; -Intelligent cruise control (ICC))	-Collision avoidance, drowsy driver, and stability warning; -Driver, regulatory and administrative information; -ICC and electronic braking systems	-Collision avoidance warning; -Driver information	-Collision avoidance warning; -Driver information; -Control assistance and intervention
Human factors	-Enhance and implement design guidelines, -Conduct DVI and driver performance research. -Conduct user acceptance testing.	-Integration research (e.g., IVIS-CAS) -Driver workload research	-Driver condition monitoring research. -Driver-fleet mgmt comm. issues -Info priority issues	-Comm. issues for driver-fleet mgmt -Info priority issues	-Comm. issues for driver-fleet mgmt -Automated control assistance research.
Tools	-Define needs and applications -Acquire, evaluate, expand, and validate selected models and tools. -Develop scenarios for models and experimental tests.	-Traffic throughput models -Dynamic traffic assignment models -Driver behavior models	-Rollover stability model -Routing strategies including time-of-day considerations	-Travel time prediction -Strategies for scheduling and routing changes	-Adapt and validate vehicle dynamics models to represent special vehicle characteristics
Architecture and standards	-Determine user needs and requirements. -Develop date requirements and define data flows and interfaces. -Develop in-vehicle data bus.	-Subsystem integration -Compatibility with car phone and other common features	-Compatibility with CVISN and other information systems	-Compatibility with other transit agency systems	-Compatibility with operating agency systems
Evaluation	-Measure and evaluate system capability, benefits, and "deployability." -Develop objective test procedures and scenarios -Conduct field operational tests.	-Response consistency (individuals and among demographic groups)	-Add' l cost-benefits: productivity; regulatory -CVO disbenefits	-Add' l cost-benefits: productivity; passenger acceptance	-Add' l cost-benefits: productivity.
Outreach	-Use RFI, public forum, and advisory committees to gather stakeholder input. -Design and conduct case studies. -Conduct periodic demonstrations.	Emphasize: -Hwy users -OEMs -Transportation agencies	Emphasize: -Motor carriers -OEMs -Shippers -Unions	Emphasize: -Transit agencies -Unions -Transit users -Government	Emphasize: -Operating agencies -Unions -Infrastructure operators

Issue Paper

Intelligent Vehicle Initiative

"Near-Term Systems" Program

Draft. 7/30/97

1.0 Introduction

This paper addresses issues relating to the "near-term systems" portion of the Intelligent Vehicle Initiative (IVI) program that is expected under the NEXTEA legislation. In referencing near-term systems in this paper, we mean the class of M systems that are closer to realization, presently covering "Level 1" and portions of the "Level 2" capabilities as currently defined by the M development team. These categories primarily include crash warning and avoidance systems, driver information systems, and certain additional functions that operate while driving is underway although perhaps in a manner transparent to the driver. The core of this subject matter comprises so-called "driver-assistance" functionalities in that they all support the human driver as the primary controller, assisting that person in the execution of driving tasks .

Issues to be addressed in this paper cover, firstly, the broad industrial, governmental, and science-knowledge context underlying the M effort. These considerations are thought to be crucial to the success of an M Program that addresses near-term systems such as identified above. The discussion goes from the general to the particular-that is, from broad views of context to a set of specific definitions, assumptions, and principles of implementation for a government-led program that fits the larger reality.

2.0 An overview of the context for R&D on Near-Term M Systems

The context contains four domains of consideration. They are:

1) The industrial context (including the outlook of the industry on driver assistance products, per se, and the process by which such products will be developed for market);

2) The federal context (primarily, the interest in ensuring public benefit from such products);

3) The context of the knowledge base from which driver assistance applications must evolve as new automotive and highway technology;

4) The extent of R & D capability and facilities supporting the M program.

The context, discussed below, indicates that we're ready to undertake serious consideration of near-term systems under an M activity but it'll take purposeful action to ensure the success of the envisioned program. The intent of the M program is to speed up the date of readiness and to increase the potential for commercial success and public benefit from driver-assistance products.

2.1 The Industrial Context

The primary industrial context that is at issue across the spectrum of near-term M functionalities concerns the automotive industry. Although other industrial segments will no doubt contribute to the provision of products and services especially in connection with a cooperative infrastructure, the role of such companies in near-term M products is not so crucial as is that of automakers and their suppliers. Nevertheless, a few other industrial sectors will be cited below. The following observations serve to sketch the industrial context:

a) all industrial players will make their decisions for M participation primarily on commercial terms. In the increasingly pragmatic milieu of modem industry, the companies participating with their own money in the M program will be those that have successfully made a case, internally, for either the business potential of the products in question or for the strategic value of improving the firm's competencies through participation. Where the business or competency case is too weak to justify the involvement, we can assume that they will not play.

b) the commercial case for IVI participation must make sense in terms of the operational practices of the company and the realities that currently govern the way they partner with others to acquire new technology, procure from their vendors, utilize their capital assets and labor pool, and market to their customers. M participation by any given company will be made more likely if the terms of participation fit better with the company's current modus operandi. This, of course, suggests that M program planners must strive to develop a dialogue either directly with industry or via intermediary channels such that internal company criteria for acceptance are recognized and the program participation requirements are matched to suit. Although some negotiation is inevitable, the program must be made prima facie attractive to its prospective industry partners.

c) there is a broad expectation within the worldwide automotive community that automotive electronics is the essential medium for new functionality in the vehicle and that remote sensing and mobile communications will be key enablers of these functionalities. Thus, the M program will not need to convince the auto industry that driver assistance products are coming, over the long term. But it will be essential that the *specific* functionalities targeted by the near-term M program align with automotive judgments on the matter of "near-ness". Put simply, "near-term" M products must be seen as feasibly marketed within 10 years, at most, in order to attract participation by the auto industry. Since an approximate 3-year lead time is needed for a new feature to be planned in an upcoming vehicle model, the attractive products must show a good chance of becoming "fully understood" in support of production decisions within a maximum of about 7 years from the launch of the IVI program in 1997.

d) on the matter of automotive judgments, three additional observations are important, namely,

1) the judgments of Original Equipment Manufacturers (OEMs, or makers of finished vehicles) are not the same as those of suppliers furnishing automotive components or subsystems to the OEM's. The suppliers are much more inclined to be pushing M technology in order to expand their businesses. Suppliers are also far less tuned into, and capable of appraising, the human-centeredness implications of such technology. Thus, suppliers are less likely to have formed their own negative judgments on "near-ness" based simply on a few remaining user acceptance problems. OEM's, on the other hand, are concerned with a host of uncertainties over the sobering requirements of M products (often tending toward delayed or negative judgments) even though they also feel compelled to advance their strategic competencies in this arena.

2) the overcoming of negative OEM judgments requires hands-on evidence obtained with fully operating prototypes and confirmation that vendors can, indeed, supply the products as required. A central drama, here, deals with defining the requirements, themselves-and the OEM's insist upon setting the requirements for the components and subsystems they procure. The OEMs must arrive at a sufficient understanding of the application and its ramifications as to feel comfortable that all the system's performance requirements have been identified. Correspondingly, the suppliers must be sufficiently involved in the creation of prototypes that they can knowledgeably enter the dialog on requirements (which is a give and take process) and eventually determine that a profitable component or subsystem can, indeed, be built per the requirements on both performance and cost. The M effort hopes to accelerate the pace of product introduction by stimulating system prototyping and field trials such that the industrial partners are able to define the performance requirements more readily and begin an earnest assessment of the manufacturing task, sooner. ln the end, the OEM, alone, will determine whether the requirements' coverage is both necessary and sufficient. (Uncertainty over requirements has been a significant part of the delay in launching adaptive cruise control products, in many auto companies.)

3) supplier judgments about product readiness also hinge to some degree upon how their envisioned product is to be integrated onto specific vehicles. This issue is highly significant since it is expected that many of the near-term M functions would be marketed, if at all, via OEM products (Le., new cars or trucks) simply because a high level of integration with other vehicular subsystems is necessary. Indeed the difficulty of integration in modem automotive electronic systems accounts for the unfeasibility of aftermarket installations of electronic items that would need to "talk to" the engine, transmission, chassis, or body electronics control units (ECU's). Further, the typical OEM company conducts their own integration engineering rather than farming it out to their suppliers. In passenger cars and light trucks, the electronic systems architecture within which this

integration occurs is unique to at least each OEM company and perhaps even to each differing vehicle platform, or model line, within the company.

Thus, a multitude of differing communications interfaces must be satisfied if a supplier is to deliver to many platforms in the light vehicle market. The differences between platforms can involve not only the communication protocols but also different partitioning of a given subsystem, thus influencing how much is supplied vs. how much is produced internally by the OEM or by yet another supplier. If an item is wholly new on the market (like most of the IVI system candidates would be) there is no prior art showing the preferred schemes of integration and system-partitioning across the industry. Thus the interested supplier faces a good deal of guesswork regarding the product configuration that will readily interface with many OEM platforms. The guesswork implies investment risk-and greater risks tend to cause the more uncertain system opportunities to be deferred.

When a supplier makes a business case for investing to develop and manufacture a certain driver assistance product, the case will include an estimate of the range of OEM vehicle platforms that are likely to be supportable by the product. While a high level of uniformity in system configuration requirements would certainly be nice, the currently immature stage of most driver assistance features is such that agreement on even the basic functional requirements would be a big accomplishment.. This is the practicable need that can be addressed through the M program. Of course, a common electronics system architecture across all light - duty vehicles would also strongly facilitate these innovations, but this is not the case in modem passenger vehicles and its achievement is expected to be a long time coming. More on system architecture will be covered in section 3.0.

e) a great deal of component and system-level prototyping of driver-assistance systems has already occurred within industry, albeit more heavily among overseas manufacturers than domestically. Thus, it should be a strategy of the M program to target those functionalities for which preceding industry investment has already prepared the basis for working prototypes. There should be openness to M participation by both foreign and domestic manufacturers if the goal is to bring the best innovations into common usage as soon as possible. The level of prototype needed for this kind of work is commonly called a “beta-” (or in Europe, “B-") sample constituting an engineering model prepared on the bench without production tooling. Such systems incorporate many of the technological aspects of the intended product, and almost all of its functionality, but lack reliability and, of course, are very expensive on a unit basis.

f) “integration” in the sense of combining multiple driver assistance functions within individual vehicles for the sake of studying synergies and conflicts is not known to have occupied much attention from the automakers, to date. In this regard, the M program is charting important territory that does not appear to have been yet given the consideration it will eventually need by industry. On the other hand, since the matrix of driver assistance combinations is virtually limitless, one must consider ***very carefully which*** functions are especially deserving to be combined in an integrated manner-recognizing that each combination will be more or less unique and thus reduced in likelihood of hitting a marketable niche right on the nose.

g) it appears to be generally true that the automotive industry wiil not offer any product feature for sale which depends upon a cooperative infrastructure that has not been largely installed prior to product launch. While one can imagine marketing certain kinds of products on a regional basis, as supported by only a regional infrastructure, the OEM's are likely to defer from offering new vehicle products on such grounds. No manufacturer wants to aggravate the customer with expensive product features that do not work when the owner travels out of the region or permanently relocates into the "land without infrastructure". Further, if the functionality is inherently a crash countermeasure, the automaker will be deeply concerned over driver expectancies that become violated in areas where the necessary infrastructure is incompletely deployed. Although an automatic feature could perhaps sense the infrastructure's presence and alert the driver to system unavailability, each such alerting event will be associated with some degree of customer dissatisfaction, perhaps leading to warranty claims or at least to a feeling that value was not received.

Moreover, the burden on cooperative infrastructures that complement OEM vehicle products is that of a priori deployment. The views of auto product planners should be sought in order to ratify whether any gradual strategies of infrastructure deployment could practicably enable an OEM product launch, given the function in question.

h) another enabling technology that begs the industrial context for an M program is that of map databases which are augmented with station-by-station data on highway geometrics. That is, the performance of certain driver assistance aids such as lane-keeping, road departure prevention, in-lane collision warning and avoidance, and others could be markedly improved, in principle, from an integrated database describing the immediate and upcoming radius, superelevation and, perhaps, grade of the roadway. The industrial issue is, could the large investment for the development of such a database be financed through private capital, only? Consider that the current map database vendors have had the benefit of diverse non-automotive markets for the early sale of their geocoded map databases. Thus the crucial early return on their map database investments (of the order of $50 to $100M for the US road network) did not depend on the mass-marketing of automotive navigators. Map databases were initially sold to local and regional customers concerned with various pick up and delivery services, GIS-based improvements in local administration of electoral rezoning, water distribution, street maintenance, etc., the dispatching of police-fire-rescue fleets, planners of local marketing strategy, and so on.

By contrast, no significant commercial market aside from that of driver assistance products is believed to exist for a detailed geocoded database on highway geometry. Thus, the investment to develop such databases must proceed on speculation that OEM driver assistance products, alone, will be forthcoming soon enough for a good financial return.

It is a further reality that the OEM's would insist on very high reliability in the geometric entries of such a database insofar as a critical safety functionality may become foiled by a database error. To understand the automaker's reliability concerns, note that a simple copy of the database containing the error would constitute rather solid evidence of fault if a related accident occurred at the site coinciding with the error. Accordingly, M concepts that would assume availability of a commercial database containing microscopic highway geometrics should first be ratified by inquiring of the map database purveyors on the commercial feasibility of such a database product.

2.2 The federal interest in ensuring public benefit from such products

Federal involvements should trace to the missions of respective DOT agencies for improving safety, traffic efficiencies, fuel economy, transit services, air quality, etc. The underlying proposition for federal investment is that a public M program will move up the timetable upon which publicly-beneficial innovations will come into common use.

Aside from the question of accelerating the introduction of driver assistance products, an underlying assumption for government initiative in this arena is that industry may not be relied upon to maximize the public-benefit attributes of the products. Rather, industry may have the view that marketability is determined primarily by the comfort and convenience features of certain products. The issue of "safety vs. convenience", for example, is certainly swirling around the adaptive cruise control product, at present. There is also public sector concern to determine the traffic flow impacts of ACC, but no industrial initiative to explore such an issue is likely.

On the one hand, the federal participants could take the view that the M program should insist on maximum public benefit from each candidate function. On the other hand, an overemphasis in this direction could very well discourage industrial interest if it appeared to divert too far from a truly marketable balance. Recognizing the need for balance, the federal role must still ensure that reasonably-achievable public benefits are identified. Further, the associated system features to attain such benefits must be prototyped and demonstrated as packages that appear to be eventually marketable .

Already, clinical estimates of the safety and traffic flow benefits deriving from various driver-assistance products have been generated by NHTSA and FHWA to help guide M prioritization. Estimates of crash-avoidance payoff, for example, have served to focus NHTSA's ITS Strategic Plan on selected countermeasures. Seeking to "enhance understanding of the trade-off between desirable and achievable systems...", the NHTSA plan inventories each of the various crash avoidance system types in terms of current understanding of system capability, user acceptance and benefits. In so doing, it serves to line up the differing systems in a way that roughly aligns with the M staging of Level 1 and 2 concepts- at least as regards crash avoidance systems.

Benefit estimates derived through FHWA research, ITS Committees, workshops, and other sources have bracketed the expected improvements in macro traffic flow and in some cases fuel savings resulting from individual usage of navigation, route guidance, and traveler information services. Savings from automatic toll collection have also been broadly assessed through the various quasi-public corporations that manage toll roads, tunnels, bridges and other facilities. Accordingly, the public benefits have been at least roughly scaled as an aid in program planning. Clearly, refined and more detailed estimates of benefits are needed if infrastructure deployment investments are to be justified and major new safety products stimulated.

Other aspects of the federal context for the near-term M systems include the issues of cooperative infrastructure, federal motor vehicle safety standards, and broad concerns with the national economy:

Cooperative infrastructure - publicly financed

The most notable enhancements to public infrastructure, at present, are occurring in the context of ATMS installations yielding traffic surveillance coverage in urbanized areas and automatic toll collection at toll facilities, especially in the Northeast. A number of metropolitan areas are experiencing sufficientiy extensive deployment of traffic detectors and centralized data processing capability that only certain institutional innovations are needed to make the data available to independent providers of services via cellular phone, pagers, and other driver advisory devices. Since both toil tags and driver advisory radios are installable as aftermarket items (not requiring integration by the OEM cat-maker) the markets for these devices can develop at a pace constrained only by the growth in infrastructure and consumer interest.

Novel additions to the highway infrastructure that might complement collision warning and avoidance products or related control enhancements to the vehicle might include the following:

- iocation-specific transponders or other devices giving localized hazard alert to drivers of vehicles having a cooperative receiver and display capability;

- cooperative provisions in lane-edge markings or other roadway or rail-crossing features that might interact with road departure warning, vision enhancement, or perhaps drowsiness warning systems to render higher levels of performance than can derive without the special provision.

In any such cases, the significant issue discussed earlier involves the extent of infrastructure coverage needed before the corresponding in-vehicle market becomes viable. We can also pose the converse question to the highway community, "what commitment by automakers is needed (and Iegally binding?) before any large public investment in cooperative infrastructure is undertaken?" Indeed, what basis do public sector policymakers have, at present, for anticipating that the auto industry will even consider giving assurances of complementary product offerings by any certain date? The product planners in auto companies are keenly aware that automotive markets tend to exaggerate the fluctuations in our macroeconomy and that buyer resistance to costly and unfamiliar product features could very well occur. To understand their outlook, note that publicly-traded commodities have established futures exchanges in order to spread the risk and potential rewards of speculative investment in those areas of commerce. But there is no "automotive futures exchange". Rather, the risk of incorrect investment justification is borne entirely by each company that is involved, even though product demand tends to take large swings from time to time.

The only clear guidance that can be given for such reflections is that if cooperative infrastructure is viable at all for enabling driver assistance products, the infrastructure elements must be a) exceedingly inexpensive, b) easy to install, c) technologically and environmentally durable, and d) non-controversial as seen by at least the 50 state DOT's and perhaps the thousands of units of local government that may need to participate in their installation and maintenance.

On the matter of "durability" the most troubling aspect is probably the very volatility of the electronics arena, itself, with the prospect that the selected cooperative technology would have obsolesced before the enabling infrastructure installation is complete. Along these lines, it is interesting to note that with private communications infrastructures, the inexorable demand for more capacity has kept the service providers technologically agile and had underwritten the wholesale renovation of their switching and transceiver equipment on the order of every 5 years or so. Thus, the question of obsolescence in these private infrastructure technologies is moot. With each transition, however, the service provider goes overboard to continue supporting the installed base of mobile units since they are the source of his revenue. Playing out an analogy to cooperative driver assistance systems, then, one could imagine that automakers would steadily advance the technology of the in-vehicle unit as long as the installed base of cooperative infrastructure remained strongly supportive of the desired functionality and performance levels. This outcome implies that the OEM's-and their customers--continue to perceive value in the cooperative function(s) such that market demand for the in-vehicle items is strong.

Since federal dollars are a large portion of total highway resources, leverage does exist for ensuring that state and local highway agencies would follow a national standard if they chose to implement cooperative enhancements to the road infrastructure. The matter of ***ensuring*** an effective pace of implementation is another question, however, given that state and local agencies will exercise their own priorities in allocating funds, unless further incentives (or mandates) are added to the equation. Presumably, this latter item will constitute a crucial determinant of whether enhancements to the public infrastructure will materialize as envisioned in the cooperative concepts that are on the M agenda

Cooperative infrastructure - privately financed

While private infrastructure is not a federal issue, per se, it is addressed here insofar as its development may complement the public interest in M systems. The forms of private infrastructure that may significantly affect implementation of near-term M systems include those for mobile communications & mobile financial transactions. Mobile communications, of course, represents a surging area of current investment that offers to dramatically expand the opportunity for communicating data to and from vehicles. Since many mobile communications services link through the publicly-switched telephone network, they support traffic advisory, routing, and a host of traveler information services that are ground-based, including traffic control centers, commercial databases, retail businesses, etc. Such regional and even national communications media are definitely developing well in advance of any demand based upon near-term M-type products. On the other hand, dedicated short-range communications (DSRC) stands out as one mode of mobile communications that, while offering distinct public value in certain highway applications (such as CVO administration, toll collection, hazard advisory, in-vehicle signing, etc.), is of relatively small interest from the viewpoint of delivering commercial services, at present. Thus, DSRC installations are expected to develop initially as public or quasi-public (toll) infrastructure.

Mobile transactions serving the purely private sale of goods or services have not emerged as yet but are also considered to be inevitable. When they do materialize, it is assumed that the functionality of the in-vehicle units can readily embrace features having public value. The path for such developments is largely unknown and unexplored at present, although DSRC standards are likely to apply since the typical transaction will be at short range.

The bottom line of the discussion on cooperative infrastructure for near-term M systems is that it will be very difficult to resolve the chicken ‘n egg standoff between highway agencies and automakers, where new public infrastructure is at issue. Of course, local development of infrastructure could still find a rapid, local, market response if the matching in-vehicle device is supportable as an aftermarket installation. While this was, indeed, the wildly successful path for launching the cellular phone, rather little of the near-term family of M systems appears addressable through this model. Instead, many of the systems in question require sophisticated integration with the OEM vehicle such that any cooperative implementations would require broad, perhaps national infrastructure coverage before OEM production would likely begin. If undertaken over a long installation time, the issue of technology obsolescence in this infrastructure would be of central importance.

The prospect of Federal Motor Vehicle Safety Standards

The fact that NHTSA has statutory authority for promulgating FMVSS regulations has a very significant effect on both the behavior of the auto industry as collaborators with the government in safety-related R & D and, indeed, in the general development of new products having safety-related functionality. Thus, the possibility of FMVSS action occupies a significant place in both the federal and industrial contexts for the M program. NHTSA’s new Strategic Plan, for example, acknowledges that mandated standards may be appropriate, although negotiated rulemaking is the preferred path toward consensus on safety performance specifications. In anticipation of the FMVSS possibility, however, industry may prefer to play certain roles in an IVI program, instead of others. It will be important, in this context, to solicit industry views on participation as the program planning evolves. Such views are known to include both a certain apprehension over the unpredictable nature of federal standards development as well as a genuine desire for certain cooperative standards that may help blunt the liability in marketing driver assistance products. Whatever the industrial views on this issue, it is certain that NHTSA's authority as a regulator will constitute a pragmatic consideration in the M participation by automotive (especially, OEM) companies.

Matters associated with the national economy

Because the federal administrative role in any governmental program is ultimately accountable to Congress, the industrial and social impacts of the activity may well be perceived in light of political themes. Accordingly, for example, it is likely that the impact of M participation on the international competitiveness of firms will be an issue of some concern. In this regard, is seems likely that some foreign-based companies will be able to offer either more advanced technology, more experience in near-term driver assistance applications, and/or more enthusiasm for collaboration than some domestic counterparts. Such a development should be anticipated in the setting of policy on M participation, balancing off the desire to accelerate the launch of publicly-beneficial products against the national concerns that trace ultimately to domestic employment and the health of a major domestic industry.

2.3 The challenge posed by modem driver assistance functions.

As the IVI program undertakes to address a broad array of driver assistance systems, we should be generally aware that the tack upon which we are sailing is into truly uncharted waters. The basic question is, "how hard will it be to get each of the various system concepts into a truly market-worthy stage of development? Scaled against the perspective of the 100-year history of the motor vehicle, it seems fair to suggest that technological assistance in the driving process, itself, will be a profoundly challenging stage of automotive advancement. After all, we're designing a technology to fit the perception, cognition, and behavior of virtually the entire citizenry, in an everyday-safety-critical function.

The challenges come from the technical bits and pieces, the severe cost/value constraints of the mass consumer market, the complexity of the host driver's interaction with the installed system, and the need for compatibility with the "socio-traffic" environment within which technologically-assisted driving must occur. Among these, the last two appear to pose the biggest stretch. Along these lines, it is not uncommon to hear auto engineers make comments like: "we can very likely build it if you can totally describe what it must do." That is, neither the hardware and software technologies nor the mass production and assemblies thereof probably constitute insurmountable barriers. Thus, it is useful to reflect briefly on the "what it must do" part of the problem.

In a nutshell, those systems which offer to assist the driver in vehicle control or in driving vigilance must elicit intuitive human interactions which turn out to be overwhelmingly satisfying. If we pose the auto engineer's question to a sample of layperson drivers-viz., "just tell me what you want!"-the likely response will be, "I can't, but I'll know it when I see it". At root, this conundrum traces to the issue of right-brain, left-brain differentiation among human tasks. Driving is overwhelming an intuitive, right-brain activity and is thus largely isolated from the deductive, left-brain ability to explain. This boils down to a tremendous burden for empirical work. It is necessary to complement driving simulators and other laboratory tools by building each system into a vehicle as a functional prototype and then trying it extensively a) with many people, and b) over many miles of exposure in order to cover the broad distribution of driving conditions in which the "satisfaction/dissatisfaction" outcome will be exposed. Only by converting such empirical experience to measured data can we bridge from intuition to deduction in driver-assistance design.

It is useful to note that satisfying the requirement for intuitively-matched systems takes the automotive requirements a step beyond those applying to aircraft. The difference is in the opportunity for training. The commercial or military pilot can be trained a priori to operate a multiplicity of assistance systems under realistically-simulated conditions, thus removing a substantial portion of the need to match intuitive recognitions in the design of the system. Perhaps most significantly, the pilot can pedagogically acquire a proper mental model of the system: he doesn't have to acquire it simply by perception through many interactive trials-perhaps still getting it wrong. The 180 million drivers in the US, on the other hand, are basically unreachable with any practicable means of training or pedagogy once licensure has occurred, and only to a limited degree, beforehand.

The socio-traffic aspect of the problem deals with how the new function given to one operator influences their driving relationship to everyone else driving nearby. Again, the elicited control actions must be so like those of a normal, capable, driver that the resulting speed and path match the expectancies of other drivers in near proximity. Designing to achieve this system quality seems to require a far more complete knowledge of the driving process than that which has undergirded much of highway design and traffic engineering to date. It simply suggests a new body of knowledge.

To put the human factors issue in its historical context, consider the domain that has been addressed through motor vehicle technology up to the present time. If we reflect on the earliest motor cars, automotive technology confined itself to the attainment of mobility, only. Provisions for braking, steering, suspension, seating, lighting, glazing, and occupant enclosure were crude, if present at all. Gradually, however, the motor vehicle became a more and more civilized machine, continuously improving in riding comfort, ergonomic adjustment, crash survivability, entertainment systems, climate control, etc. The quality of subsystems by which the driver controlled speed and path also steadily improved so that long-distance driving tended to become less and less of a chore.

But, throughout this epoch, no aspect of automotive technology ever tried to accomplish what the human driver does with his/her eyes in terms of assessing the immediate need for speed and path control. Rather, the remarkable capabilities in human visual performance and the higher cognitive faculties by which risk-taking is judged and control adaptation occurs surely explain a great deal about the success of the motor vehicle, under human control. Thus it is a bold proposition that automotive technology would soon begin to occupy parts of the functional space previously covered only by human perceptual and cognitive capability. Doing it on a simultaneous, "co-pilot" sort of basis such as envisioned in near-term IVI systems makes the user compatibility goal even more challenging, but presumably offers a final driver/vehicle system that is more robust.

One way of exposing the significance of the challenge is to say that we just haven't developed much science on the driving process. This has great implications when it comes to generalizing from ad hoc results obtained with vehicle-based prototypes. Noting that IVI planners seek to combine (or integrate) ***multiple*** differing functions within individual vehicles for simultaneous operation by individual drivers, the lack of an underlying science suggests that it will be very difficult to extract generally-meaningfui information from such driving.

Surely as the number of active systems goes up, the resulting matrix of functions will tend to make the test results unique and non-generalizeable. Experimental variation in quantitative parameters for each system is tough enough, since the interactive states of the multiple systems rises exponentidly. But the presentation of multiple innovative ***functions,*** per se, poses a very great methodological challenge. The prospect looms large of a bewildered M test subject facing too much novelty all at once such that every driving test is quirky and more or less unique.

Thus, from a research point of view, more can definitely be less. That is, the more one integrates differing functionalities together onto a single test vehicle, the less useful information one may gain on the phenomena that determine user performance and acceptance and on a reasonable extrapolation toward long-term benefits. Moreover, it seems that this elephant should be eaten a very few bites at a time.

Having mentioned the complexity posed by combinations of multiple, unnamed, systems we must also acknowledge that all system types in the IVI program do not present the same level of challenge for human operation. Surely, the provision of traffic information via visual display or audible messages does not pose the same driver-interaction drama as does an automatic path correction to prevent runoff-road. Indeed, systems falling into the "driver information" category pose safety questions by their workload demands and user acceptance questions by their operability and functional match-up to driver needs. Crash warning and avoidance systems pose safety questions directly by their functional definitions, but workload is a non-issue because such systems are in a quiescent state throughout normal driving. The CW/CA safety issues break down further into the appropriateness of the alarmed responses on the short term and risk adaptation on the long term. At the benign end of the human challenge spectrum, automatic collision notification or automatic debit transactions seem to present virtually no demands for driver interaction, at all.

In terms of designing the M program, these reflections suggest that not all system concepts on the Level 1 and 2 lists, and certainly not large numbers of system concepts combined, seem to warrant prototyping within the term of this effort. Nevertheless, the high payoffs projected for many of the targeted concepts justifies their examination and the advancement of those systems for which true solutions emerge.

2.4 Research Capability Supporting These Developments

Noting the challenges cited above, it is important to reflect on the means for finding a way out. The research resources that are either already available or are becoming developed toward a scientific approach on M system development include both professional capacity and specialized facilities.

Professional Research Capacity

The product-bound technologies of remote sensing and mobile communications have emerged almost exclusively through private organizations operating either in the commercial or military & aerospace R & D communities. A number of the automotive suppliers and some OEM's are joined to such organizations through one arrangement or another. These connections will serve as the primary technical resources through which M program prototypes will be created. In some cases, complete systems will be forthcoming from these players. In other cases, only the subsystem modules may be made available through these companies such that the task of system integration remains to be accomplished by others. In any case, the very essence of the M plan assumes participation by the automotive-connected companies whose technical competence and market delivery paths are essential for bringing driver-assistance products into broad usage.

Additional participation in the M endeavor may come through university research groups, commercial R & D contractors, and federal labs. Presumably involvement would align with the specialized capabilities of each as differing collaborations are offered jointly with the automotive companies.

Specialized Research Facilities

The M program seems certain to require the use of various specialized research facilities that are in existence or becoming available soon. Existing facilities include driving simulators, proving grounds, vehicle instrumentation systems, roadside data collection systems and specialized data processing tools and computer simulations developed, owned, or otherwise accessible by NHTSA and FHWA. NHTSA identifies the Data Acquisition System for Crash Avoidance Research, DASCAR, the System for Assessment of the Vehicle Motion Environment (SAVME), the Variable Dynamics Test Vehicle (VDTV) and (by 1999) the National Advanced Driving Simulator (NADS) facilities as primary tools for supporting research on the near-term M systems. FHWA is advancing its driving simulator at Turner Fairbanks, a Human Factors Field Research Vehicle (HFFRV), and other facilities for studying nighttime conspicuity enhancement and cooperative highway markings. In addition, established contractors have developed substantial levels of capability in data collection, processing, and interpretation relative to the evaluation of driver assistance aids.

3.0 Assumptions, Definitions and Principles Underlying an M Plan Covering Near Term Systems

Having covered a variety of context issues, above, with reference to a vaguely-described M agenda covering near term systems, this section is intended to put a tighter focus for defining this portion of the overall program. In order to gain this focus, a brief excerpting from the draft text of subsection 6055(b) of the Administration's draft of NEXTEA is cited first for perspective. Basing assumptions and definitions on this draft of the bill does not presuppose the survival of this language, per se. Rather, it expands the thought process surrounding an M-like endeavor, generally, whatever specific language may arrive in the eventual legislation. The suggested set of assumptions and definitions are presented by way of further foundation for the structuring of M work on near-term systems.

3.1 Excerpts from subsection 6055(b) of draft NEXTEA

The M program would be authorized using generalized terms, profiling the effort in the following way:

- as a "research and development" activity
- for the purpose of "demonstrating"
- that which **is** to be demonstrated is "integrated inteiligent vehicle systems"
- "state of the art pre-production systems" are to be included
- that which is to be integrated in such vehicles is:

  collision avoidance

  in-vehicle information

  other safety-related systems
- the work is to incorporate human factors research findings to "improve situational awareness and ensure success of the man-machine relationship"
- it is to "build on the technologies" developed via NHTSA's OCAR and FHWA's AHS programs
- the work is to be cooperative with industry, universities, & others.
- the funds, $25M per year, are to be taken from the $96M authorized as the "ITS Research and Program Support Activities" provision of the "Intelligent Transportation Systems Act of 1997".
- this funding is described as having replaced the provision in the ITS Act of 1991 for 5% of funds that were authorized for "high-risk innovative tests with significant potential to accomplish long-term goals".
- the effort is further characterized as "long range research activities with private entities" wherein the federal share is limited to 50% of project costs.

3.2 Definitions, Assumptions...

Working definitions and assumptions are suggested as follows:

1) The primary vehicle of interest is a light-duty passenger vehicle, but commercial motor vehicles and transit buses may also be included in the scope of the effort.

2) The system types in question are described as advanced vehicle control and information systems and are intended to assist the human operator directly in the driving process. In the context of collision avoidance, the assistance constitutes control action, a warning that control adjustment is needed, or at least an alert on speed, path, and proximity to other vehicles. In all cases, the human driver still maintains supervisory authority and a central role in control modulation, based upon continuous vigilance. In the context of driver information systems, the assistance supports the driver's tactical planning of speed, lane choice, and route links, more or less as a side-task while driving is underway. The broad purpose of this overall class of systems is to upgrade a) system safety in terms of avoided or reduced-severity crashes and/or b) efficiency, thereby conserving the resources of time, human effort and driving capacity, motor fuel, highway throughput capacity, etc. Successful products of this type will require deliberately "human-centered" designs.

3) Human-Centered design refers to the complementarity of the system to its human users, given the psychological and physiological attributes of people as they have evolved throughout the history of the human species, have been conditioned through modem culture and personal driving experience, and have adapted to the immediate vehicle package since first driving it. Given the ubiquity of the motor vehicle, it goes without saying that "human-centeredness" also implies a virtual "population-centeredness" insofar as the vast multitude of drivers must find the system to be complementary to them as individuals, however they differ from one another (although some exclusion of system suitability is admitted for cases of debilitating handicaps and excessively aberrant behavior.)

Human-centered design has been largely achieved, already, in most conventional automotive products through trial and error and the self-selection of the market. This fact is demonstrated by the high level of driver satisfaction with modem motor vehicles, implying that automotive products do indeed evolve toward human-centered design, however fitfully during the initial stages of each innovation.

As we move into driver assistance systems, however, many of the functions significantly modify the driving task in ways that are potentially critical to safe operation. And a multiplicity of systems implies a much heightened need for human-centeredness in the ensemble. This situation suggests that human-centeredness qualities must reach a rather high state before driver assistance products become marketed to the public. Thus, while the automotive tradition begs for an evolutionary process of product refinement, with the market serving as a key learning environment, this particular wave of innovation needs special precaution against early products that are crude to the point of harmfulness. We should recognize that caution over human-centeredness qualities may typically burden the development and launch of these products, probably to the point of indefinite postponement of commercialization plans for some system types.

4) Testbed vehicles will be created as research and demonstration platforms for studying and showing integrated installations of driver-assistance systems. While fundamentally dissimilar systems might be integrated on some platforms, (for example, systems for road-departure prevention and navigation) other integrations would encompass multiple features and modalities of a single basic system (for example, adaptive cruise control with provisions for forward collision warning and forward collision avoidance.) In the prior category, the R & D platform reflects a future marketing scenario in which multiple system products would appear simultaneously on a given vehicle model. Human centeredness in such cases is concerned with the simultaneity of driver tasks and interactions. In the latter category, the R & D platform relates to a scenario in which thematically-related products might appear in an integrated bundle, perhaps posing challenges to the driver for assimilating an accurate mental model of the package. Thus, the human-centeredness issues involve adaptation to a collection of complementary functionalities.

5) A spectrum of system maturity levels is anticipated among even the near-term M systems. Systems selected for integration under this program would ideally be fully functional at the outset or at least show promise of evolving into a fully functional, engineering prototype within the course of the program. Desirably, systems will be operable over a reasonable range of traffic and road conditions. In such cases, the premium would be put on assessing the performance capability of the system, the level of user-acceptance associated with the assistance function, and sufficient evidence of actual operation as to base quantitative estimates of expected benefits.

On the other hand, the state-of-the-art character of the installed technologies may imply that usage of certain vehicles by laypersons on the public roadway may not be appropriate (and, by implication, human use review panel (HURP) approval may not be obtainable.) Also, a relatively high level of prototype maintenance effort should be assumed, especially for systems that are earlier in their state of development.

6) The research and development orientation of the program implies that no vehicle will be built purely for demonstration purposes but rather will also be employed as a platform for research that extends knowledge on the system-aided driving process. Research methodologies would span from system modeling and analysis (in support of development and performance assessment) to proving grounds experimentation and lay subject testing on public roadways-when HURP-approvable operations can be ensured.

7) The utilization of a testbed vehicle for demonstration requires that at least some functions of installed systems are finished to such a degree that they can support a live (driving) presentation to policymakers, the media, and professional groups. Demonstrations would be orchestrated on closed facilities such as proving grounds and, where appropriate, conducted on public roadways. Highly refined platforms could be provided to selected persons for their own operation in traffic.

8) Every qualifying vehicle should include at least one collision avoidance system (per the NEXTEA definition of such a system) in recognition of the strong safety theme of the legislation as a whole. The selected collision avoidance systems will, in turn, be qualified at least in part, by the extent of the safety benefits which have been projected through

NHTSA research [as summarized for various system types in NHTSA's ITS Plan (1997-2002)] .

9) In order to tie this program to the deployment concerns of the ITS Act of 1997, as a whole, special priority should be given to those system types for which study under the M program would most accelerate the industry's readiness for market launch in the US.

3.2 Implementation Principles-M testbeds for near-term systems

The implementation of driver-assistance systems as R&D testbeds will be guided by the four principles enumerated below. The principles are as follows:

1) Each vehicle that is equipped to support research and development (i.e., an "R&D Testbed) will include one "Prime Safety System" (PSS) and one other selected system. Thus, R&D Testbeds will all be integrated on a two-at-a-time basis if they involve fundamentally dissimilar functions, or in a thematically-linked ensemble of features, with safety functionality as the lead, or prime, item. Additional systems beyond these two may also be installed on an R&D testbed vehicle for demonstration purposes as long as their presence will not preclude experiments and field tests involving only the two selected systems. This approach accomplishes the central objectives of highlighting safety-beneficial technology while also integrating other systems on a scale that renders the research practicably-manageable. The "safety-benefits" potential for any candidate M package will be assessed in line with the priorities of NHTSA's Strategic Plan for '97-'02. The concern for "practicably manageable" testbeds argues for system packages that can be reasonably explained to individual human subjects within a sixty- to ninety-minute orientation session in order that meaningful human-use research can be conducted with each of the R&D testbeds. (On the strength of evidence coming in from active Field Operational Tests, such as the ongoing test of ACC and previous tests of route-guidance/navigation systems, it is believed that two innovative driver-assistance systems will typically constitute this practically manageable limit.)

   The "PSS" designation will apply to systems such as:

   - Collision Avoidance Warning Systems (CAWS) - rear-end, (RE), road departure (RD), and Lane Change (LC)
   - Adaptive Cruise Control (ACC)

   which are believed to either pose significant safety benefits, themselves, or to lie along a product/market development path that peculiarly advances toward crash avoidance goals. One other system will be integrated at a time with each PSS package, on the basis of the following criteria:

   a) the "other" system is expected to become successful on the market by 2004,

   b) it needs special treatment in order to prevent interference with the effectiveness of the Prime System and/or,

c) it offers compelling synergistic features by which the safety quality of the Prime System may be further enhanced. (as an example of such synergies, consider the near-term case of Adaptive Cruise Control (ACC) combined with Navigation and Routing (NAV). Since the NAV system geolocates the vehicles on the road system it can offer safety enhancements to ACC such as:

- detecting a freeway-exiting path or a freeway-to-freeway interchange, whereupon ACC is deactivated or the driver is advised to do so;
- anticipating a toil plaza or freeway terminus where traffic stops, thereby, prompting driver on likely need to intervene ahead;
- anticipating route link transitions and prompting ACC driver on lane choice and set speed values commensurate with transition ahead;
- employing dynamic traffic data, prevailing road type, and vehicle location for suggesting optimum headway time and set speed for conditions.)

2) There must be practicable installations of M packages within production motor vehicles. The intent is to minimize cost and expedite the build-up process, albeit with inevitable constraints that are dictated by details in the OEM design of the platform vehicle. Each installation must benefit as much as possible from the prior engineering work done by industry in creating the active system prototypes. Thus, the design (and underlying architecture) of each system prototype will not be re-engineered significantly in order to effect the IVI implementation, nor will there be significant re-engineering of the OEM platform, itself.

This practicality flushes out the issue of in-vehicle architecture. That is, the need to employ, with negligible modification, the massively complex software in the ECU's for the engine, transmission, and brake (i.e., ABS or traction control) systems typically requires that the production ECU's be used more or less as designed. Thus, the prototype system may communicate with the ECU's via the diagnostic service connector both to get status information and to put functional commands. As such, this "architecture" would be fundamentally ad hoc in nature (clearly, no production-worthy architecture would use the diagnostic connector as a full-time path for communications.) Moreover, while testbed implementations will yield insight on architectural issues for the eventual product, the prototype installation will not, itself, approximate the eventual architecture. (This point of view is also realistically in line with automotive industry practice whereby electronic system architecture differs profoundly from company to company and from one product line to andther within certain companies, as mentioned earlier. The resulting architecture seen on modem automobiles is determined as much by practical constraints on cost and the incremental nature of product evolution, given the supplier/OEM procurement relationships, as upon technical considerations.)

3) The premium will be put on getting as authentic a feel and function of each system as possible, even though the means of achieving this functionality may differ significantly from that of the eventual automotive product. This point needs careful attention. We must be convinced (with automakers' help) both that an actual product implementation of this function is feasible and that the implementation of our prototype does not misrepresent that product-feasible function. The principle is that the prototype function must be authentic-it is less

important that the prototype form be authentic than that some product-realizable form be reasonably attainable. (It is likely to be necessary, for example, to implement special active elements in the brake light circuit, the audio system, the dashboard display elements, turn signals, etc., none of which is truly suited to production but which achieves the targeted functionality on the M prototype. In every case, the M purpose is to assess the extent to which the prototyped function is attractive and effective for a population of lay users.

4) Systems will be enhanced to maximize user-acceutance and safetveffectiveness. That is, whatever the functional range of an original system that was developed by industry as the basis for each prototype, the M application will seek to achieve the most user-acceptable and safety-beneficial implementation that the collaborating partners deem to be practicable. Along these lines, example synergistic adaptations of two companion systems were given earlier. The M program's tilt toward emphasizing the study of user-acceptance reflects the understanding that driver assistance products must be effectively human-centered in their implementation if they are to become successful as automotive products. The emphasis on safety-effectiveness obviously derives from the governmental mission in public safety-a central mandate of the IVI program. Of course the industry is also fully absorbed with concern over reaching a marketable cost, as well as the qualities of maintainability, manufacturability, robustness to the automotive environments of weather, vibration, corrosion, etc.-but none of these qualities is the suitable object for government funding toward IVI prototypes.

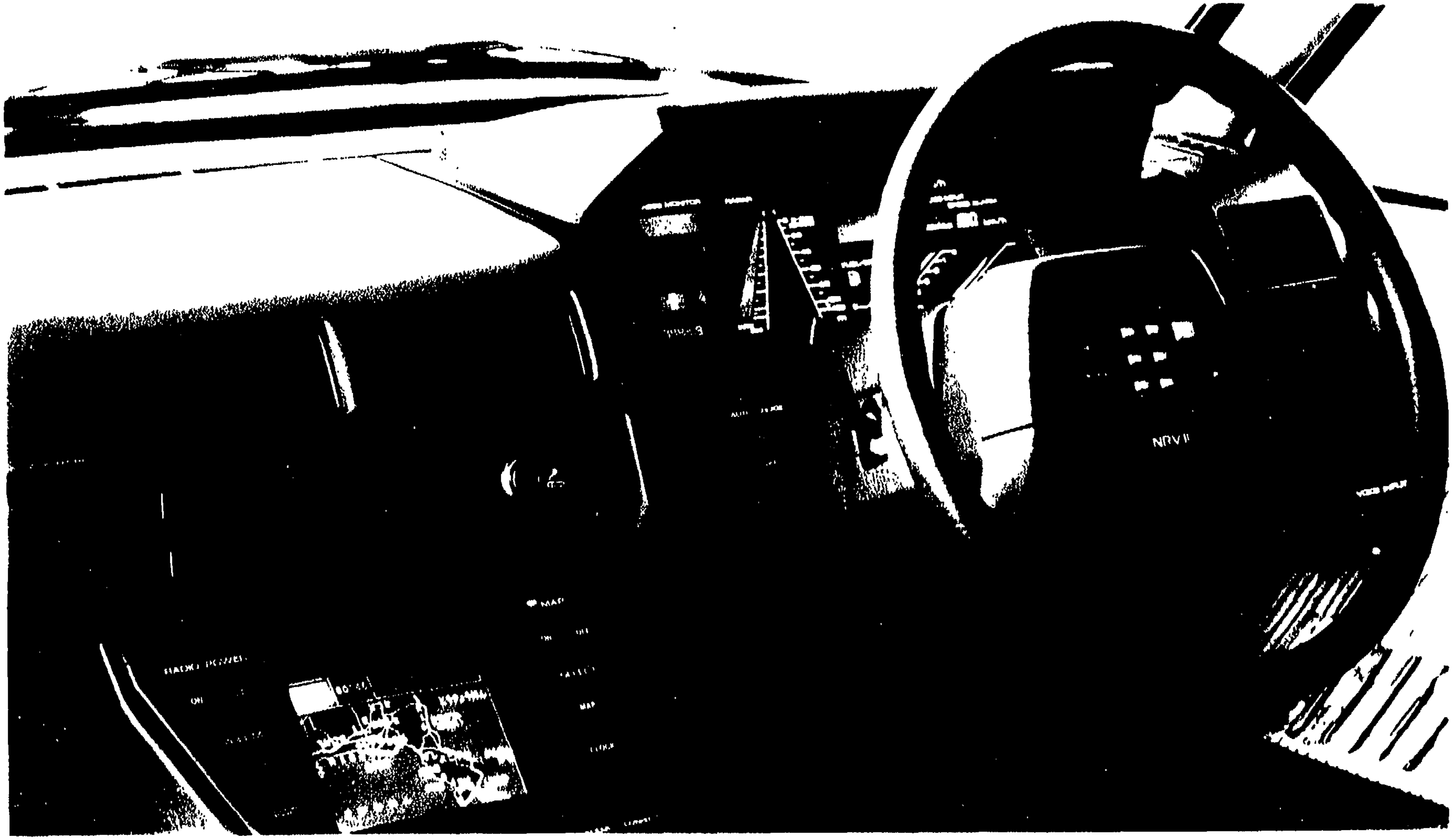
Presentation Overheads

Safety Related Activities in ITS (Japan)

August 5th, 1997
ITS America
A VCSS Committee

Sequence / System Type	Fatigue → Perception → Judgment → Evasive Maneuver → Crash → Medical Care ← Preventive Safety →
Stand-alone	■ Drowsiness Alarm ■ Proximity Alarm ■ Body Strength ■ Head Lamp Beam Control ■ Air Bag ■ Night Vision ■ ABS/4WS
Infra-related	■ Route Guidance ■ Traffic Control ■ Road Vehicle Lighting Integration ■ Automatic Vehicle Control ■ Guide-light ■ Intelligent Medical Care System

Accident Sequence and Safety Systems


NRV II

First Period

1991-1995

4 Fields of Major Safety Technologies

(1) Preventive Safety Technologies

(2) Accident Avoidance Technologies

(3) Damage Decreasing Technologies

(4) Post-Impact Injury Mitigation and Prevention Technologies

First Period

1991-1995

Participating Cooperations - 9

- Toyota
- Nissan
- Mitsubishi
- Mazda
- Honda
- Isuzu
- Fuji
- Daihatsu
- Suzuki

Second Period

1996-2000

6 Fields of Major Safety Technologies

(1) Preventive Safety Technologies

(2) Accident Avoidance Technologies

(3) ***Autonomous Driving Technologies***

(4) Damage Decreasing Technologies

(5) Post-Impact Injury Mitigation and Prevention Technologies

(6) ***Fundamental Automotive Engineering Technologies***

Second Period

1996-2000

Participating Cooperations-- 13

- Toyota
- Nissan
- Mitsubishi
- Mazda
- Honda
- Isuzu
- Fuji
- Daihatsu
- S u z u k i

New Members

- Nissan Diesel
- Hino
- **Kawasaki**
- Yamaha

The 32 Systems Technologies

(I) Preventive Safety Technologies

1. Warning System for Dangerous Driver Conditions
2. Warning System for Dangerous Vehicle Conditions
3. Vision Enhancement System
4. Vision Enhancement System in Nighttime Driving and Nighttime Object Detection
5. Blind Area Monitoring/Warning System
6. Surroundings Warning System
7. Road Environment Information Acquisition and Warning System
8. Inter-Vehicle Communication and Warning System
9. Driver Workload Reduction System

(II) Accident Avoidance Technologies

10. Intelligent Vehicle Control System
11. Driver's Hazardous Condition Detection System
12. Blind Area Accident Avoidance System
13. Collision Avoidance System with Surrounding Obstacles
14. Collision Avoidance System Utilizing Road Information

(III) Autonomous Driving Technologies

15. Autonomous Driving System Utilizing the Existing Infrastructure
16. Autonomous Driving System Utilizing Newly Installed Infrastructure

(IV) Damage Decreasing Technologies

17. Impact Absorbing System
18. Occupant Protection System
19. Pedestrian Injury Severity Reduction System

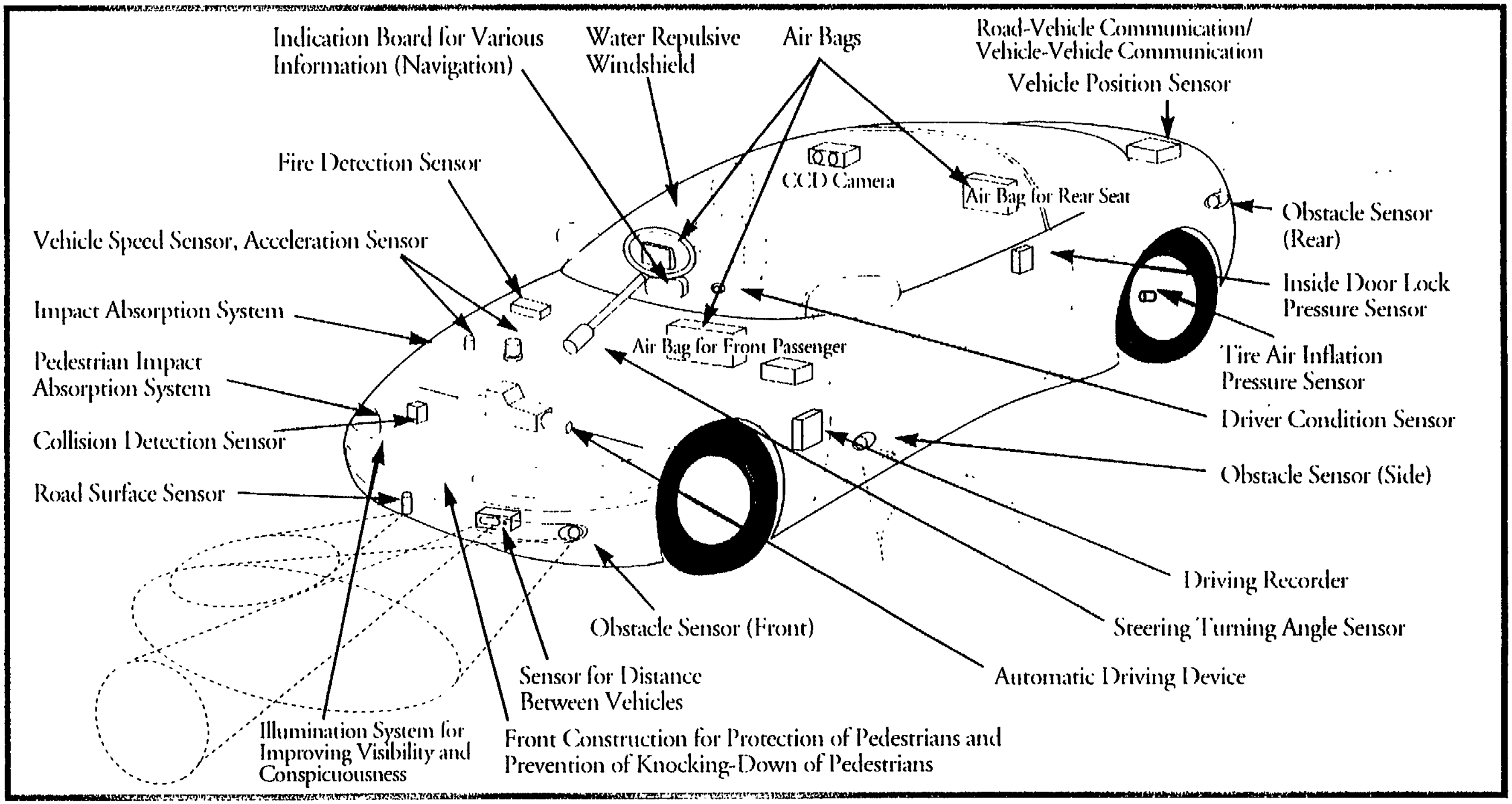
(V) Post-Impact Injury Mitigation and Prevention Technologies

20. Emergency Door Lock Release System
21. Secondary Impact Reduction System
22. Fire Extinguishing System
23. Automatic Emergency Reporting System

(VI) Fundamental Automotive Engineering Technologies

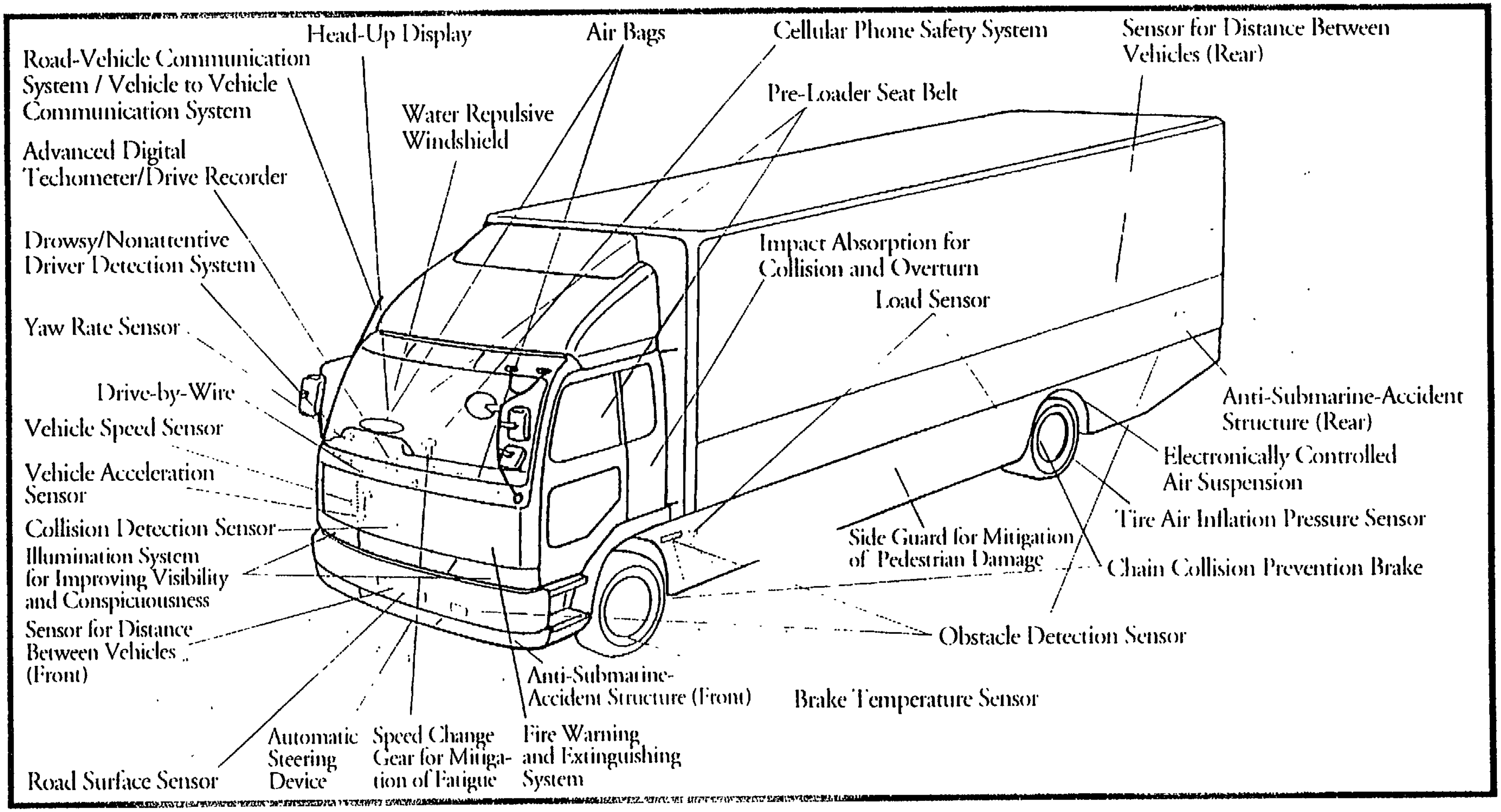
24. Safer Usage System of Cellular Phone
25. Advanced Digital Tachometer/Drive Recorder
26. Electronic Vehicle Identification Tag (Number)
27. Automatic Reporting System of Vehicle Condition
28. Advanced Global Positioning System
29. Drive-by-Wire System
30. Advanced System for Elderly Drivers
31. Physiological Detection System for Fatigued Drivers
32. Advanced Human Interface System

Image of ASV



Indication Board for Various Information (Navigation)
Water Repulsive Windshield
Air Bags
Road-Vehicle Communication/ Vehicle-Vehicle Communication
Vehicle Position Sensor
Fire Detection Sensor
CCD Camera
Air Bag for Rear Seat
Obstacle Sensor (Rear)
Vehicle Speed Sensor, Acceleration Sensor
Inside Door Lock Pressure Sensor
Impact Absorption System
Air Bag for Front Passenger
Tire Air Inflation Pressure Sensor
Pedestrian Impact Absorption System
Driver Condition Sensor
Collision Detection Sensor
Obstacle Sensor (Side)
Road Surface Sensor
Driving Recorder
Obstacle Sensor (Front)
Steering Turning Angle Sensor
Sensor for Distance Between Vehicles
Automatic Driving Device
Illumination System for Improving Visibility and Conspicuousness
Front Construction for Protection of Pedestrians and Prevention of Knocking-Down of Pedestrians

Image of ASV for Trucks



Brief Overview of Safety-Related Activities in Japan – 4

1995

- The Japanese Government's Announcement of Its "Guidelines on Increasing Use of Information and Communications in the Fields of Roads, Traffic, and Vehicles"
  - ITS Is Thus Recognized as a National Project
- The First AHS Demonstration: Car-Platooning with Cars of the Same Make

Brief Overview of Safety-Related Activities in Japan – 5

1996

- The Inter-Ministry Committee for ITS Announces the "Comprehensive Plan for ITS in Japan"
  - Nine Areas of Development
  - AHS Comes Under Two Areas
  - (1) Assistance for Safe Driving: Automation of Driving
  - (2) Increasing Efficiency in CVO: Platooning of Commerical Vehicles
    for Both Categories, the Target Is for Deployment in 2010
- Second Phase of ASV Is Initiated, with View of Integrating with the AHS Initiative in the Future. Bus and Truck Operation Is Also Included
- The Second AHS Demonstration: Car-Platooning with Mixed Models (Manufacturers)

Advanced Cruise-Assist Highway System Research Association

- Established: Sept. 25th, 1996
- Participating Members: 21 (Initial Number)
- Term of Research: 5 Years (Oct. 1996 to Mar. 2001)
- Leading Ministry: Ministry of Construction

Participating Members of AHSRA

(as of October, 1996)

- Ishikawajima-Harima Heavy Industries Co., Ltd.
- Isuzu Motors Ltd.
- Oki Electric Industry Co., Ltd.
- Omron Corporation
- Sumitomo Electric Industries, Ltd.
- Denso Corporation
- Toshiba Corporation
- Toyota Motor Corporation
- Nissan Motor Co., Ltd.
- NEC Corporation
- Nippon Telegraph and Telephone Corporation
- Hitachi, Ltd.
- Hitachi Cable, Ltd.
- Fujitsu Ltd.
- Furukawa Electric Co. Ltd.
- Honda Motor Co., Ltd.
- Matsushita Electric Industrial Co., Ltd.
- Mazda Motor Corporation
- Mitsubishi Motors Corporation
- Mitsubishi Heavy Industries Co., Ltd.
- Mitsubishi Electric Corporation

Super Smart Vehicle System: Vehicle-Oriented AVCS by MITI

Sadayuki TSUGAWA

Mechanical Engineering Laboratory, MITI

ITS PROJECTS IN JAPAN

	Vehicle-Oriented	Infrastructure-Oriented
ATMS ATIS		VICS UTMS
AVCS	ASV SSVS	MOC-ITS (ARTS)

SSVS

- ITS Studies by MITI, MEL, JSK
- Vehicle Oriented AVCS
  - Intelligent Driving System for the Future
  - Safety, Efficiency, Environment
  - Aging Society
- Current research
  - Inter-vehicle communication
  - Inter-vehicle gap measurement
  - Cooperative driving

INTELLIGENT ***VEHICLE*** *INITIATIVE*

Ray Resendes, ITS JPO
August 5,1997

The Problem

- *Technology is/will be available to increase motor vehicle safety and mobility*

  BUT........

- *This same technology could have a net effect of reducing safety*

Intelligent Vehicle Initiative - IVI

- *An R & D program for accelerating the development, availability, and use of integrated systems that help drivers process information, make decisions, and operate more safely and effectively.*
- *Vision extends beyond NEXTEA.*
- *Program plan covers duration of NEXTEA.*

IVI - Why Do It?

- *Major improvement in highway safety will come from avoiding hazards and crashes.*
- *Fewer incidents and crashes result in more lives saved, lower health care and other economic costs, and more efficient highways.*
- *Driver error is the predominant cause of highway crashes.*

IVI - Why Do It? (cont'd)

- *New technologies can help drivers operate more safely and efficiently.*
- *The IVI program is designed to demonstrate how these technologies can be applied to solve many of today's highway transportation problems.*

IVI - Who Will be Involved?

- *A US DOT multi-agency effort, which coordinates vehicle-related ITS programs.*
- *Will include partnerships with industry, States, and other organizations.*

Intelligent Vehicle Initiative Scope

- *Safety is the highest priority; encourage other benefits (e.g., efficiency, environment, comfort/convenience).*
- *Accelerated system integration with human factors considerations.*
- *Transportation modes include: cars, buses and trucks.*

Intelligent Vehicle Initiative Scope (cont'd)

- *Technology range includes: in-vehicle travel and hazard information, collision warning, control intervention, control assistance, and cooperative infrastructure.*
- *Key milestones include: early demos and field test evaluations with emphasis on assessing benefits.*

Build on Current Research

- *NHTSA'S ITS/Crash Avoidance Research*
- *FHWA ITS/AHS (includes OMC)*
- *FTA ITS [and Advanced Technology Transit Bus]*
- *FRA ITS*

IVI Program Activities

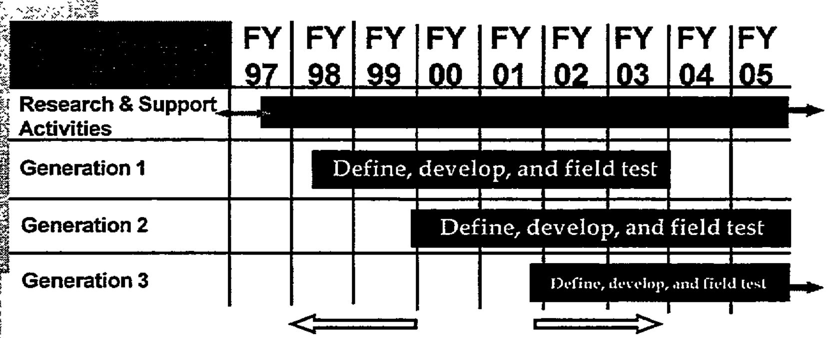
- *Vehicle and infrastructure system definition, development, demonstration, and field test evaluation*
- *Research and support activities in areas such as human factors, technology development, architecture and standards, system capability, user acceptance, benefits, and evaluation.*
- *Stakeholder participation and demonstrations.*

IVI Program Activities (cont'd)

- *3 levels of increasing capabilities and integration of multiple functional systems*
  - *Level 1 = Warning and Information*
  - *Level 2 = Driver Assistance*
  - *Level 3 = Automation*
- *Generations = Sequence of Testbeds which may combine levels*

System Development Framework

Passenger Car Example



Generation 1: Light Vehicle

Potential Capabilities

- Collision Warning
- Driver Information
- Intelligent Cruise Control

Generation 1: Heavy Vehicle

Potential Capabilities

- Collision, Drowsy Driver and Stability Warning
- Driver, Regulatory and Administrative Information
- Intelligent Cruise Control and Electronic Braking

Generation 1 Transit Bus

Potential Capabilities

- Collision Warning
- Driver Information
- Lateral Control

Generation 1 Specialty Vehicles

Potential Capabilities

- Collision Warning
- Driver Information
- Control Assistance and Intervention

IVI - What is Different?

- Proactive program integration
  - *take advantage of maturing USDOT programs.*
  - *detailed program plan development and coordination.*
  - *single budget for current vehicle-related ITS programs.*

IVI - What is Different? (cont'd)

- *Technical integration*
  - *active integration of human factors considerations.*
  - *multi-functional integration of proven component systems.*
  - *vehicle-highway cooperative systems.*
- *Concurrent system R & D*
  - *longer-term R & D linked coherently to near-term deployability*

IVI - What is Different? (cont'd)

- *Stakeholder engagement*
  - *industry, infrastructure and service providers, and other entities.*
  - *opportunity for user acceptance and market readiness evaluations.*

Next Steps

- *Prepare IVI implementation plan / Roadmap (FY 98-03).*
- *Prepare "Business Plan" for National Science and Technology Council.*
- *Outreach*
  - *Federal Register*
  - *Industry Coordination*
  - *ITS America*
  - *Industry Workshop*

NHTSA

People Saving People

NHTSA ITS
Crash Avoidance Research
I V I Forum

August 5, 1997

Joseph Kanianthra, Director
Office of Crash Avoidance Research

People Saving People

Introduction

- **NHTSA Mission**
  - Save Lives and Reduce Injuries
  - Reduce the Economic Burden
- **Department's Emphasis on Safety**

Opportunities

- **Crash Avoidance Opportunities**
  - Vehicles, drivers & environment has important roles
  - NHTSA deals with two of the important elements

People Saving People

Future Technologies

- How Can Emerging Technologies Help?

  > Applying technologies to enhance driving

  > Assist the driver

  > Use Sensing, communication and control algorithms to prevent crashes

NHTSA
People Saving People

Research Tools

- Data Acquisition Systems for Crash Avoidance Research (DASCAR)
- National Advanced Driving Simulator (NADS)
- Variable Dynamics Test Vehicle (VDTV)
- System for Assessment of Vehicle Motion Environment (SAVME)

NHTSA
People Saving People

Current Research Projects

- **Specific Collision Types**
- **Driver Performance**
- **Post-Collision Injury Mitigation**

NHTSA
People Saving People

Current Research Projects

- **Projects related to specific collision types**
  - Rear-end
  - Road departure
  - Lane change & merge
  - Heavy vehicle stability
  - Intersection collisions
- **Projects addressing driver performance**
  - Driver status monitoring
  - Vision enhancement
  - Human-vehicle interaction
- **Projects addressing post-collision injury mitigation**
  - Automatic collision notification

NHTSA
People Saving People

System Features

- **System Capability**
  - Sensor
  - Computational
  - Driver Interface

- **User Acceptance**
  - Measures of performance
    - False positives
    - False negatives
    - Nuisance warnings
    - Perceived non-warnings
    - Workload
    - Cost

- **Benefits**
  - Number of collisions
  - Number and severity of injuries
  - Number of fatalities
  - Amount of secondary congestion

NHTSA
People Saving People

Driver Vehicle Interface Warning Modalities

- Auditory
- Visual
- Haptic
- Combination of the above

NHTSA
People Saving People

Driver Vehicle Interfaces for Collision Warning Systems

- **Lane Change Collision Avoidance System**
- **Rear-End Collision Avoidance System**
- **Road Departure Warning System**

NHTSA
People Saving People

Future Objectives

- Improve understanding of system capability
- Evaluate consumer acceptance
- Estimate realworld safety benefits
- Facilitate deployment

People Saving People

Approach

- Integrate Intelligent Systems into Passenger Vehicles
- Demonstrate Feasibility
- Develop Test Procedures for Evaluation
- Evaluate Performance

Integrated Intelligent Systems Vehicle

WHY INTEGRATE?

- **Encourage Acceleration of Industry's Readiness**
  - Sensing
  - Data Processing
  - Driver-Interface
  - System Architecture
- **Provide Information on Desirability**
- **Reduce Manufacturing and Consumer Cost**

People Saving People

Integrated Intelligent Systems Vehicle (cont'd)

WHY INTEGRATE? (CONT'D)

- **Improve Marketability and Consumer Acceptance**
- **Allow Evaluation of System Performance**

NEXT STEPS

- Complete Development Research
- Identify Potential Candidate Systems
- Status Evaluation of Candidate Systems
- System Selection
- Develop Integration Plan

People Saving People

System Benefits Estimates

- **Determine realworld effectiveness**
  - Simulator
  - Test Track Experiments
  - Field Operational Tests

NHTSA
People Saving People

Facilitate Deployment

- **Estimation of Safety Benefits**
  - Number of Collisions Avoided
  - Fatalities and Injuries Prevented
- **Develop Partnership with Product Designers and Automotive Industry**
- **Develop Test Procedures & Performance Requirements**

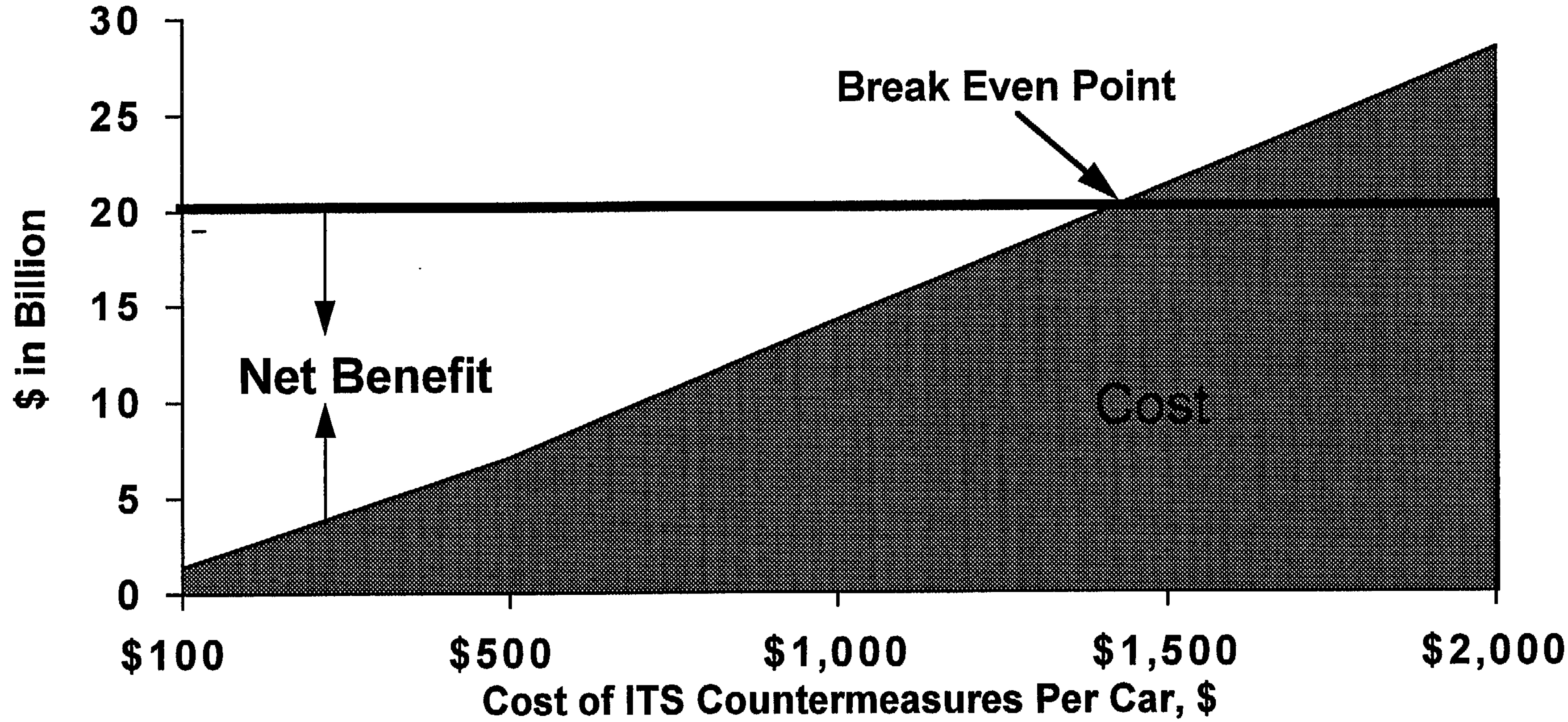
NHTSA
People Saving People

Crashes Prevented By Selected Crash Avoidance Systems

Crash Condition (1)	Total No. of Crashes (2)	Relevant Crashes Addressed by Countermeasures (3)	Effectiveness Estimates (4)	Number of Crashes Reduced (3) x (4)
Roadway Departure	1.2 million	458,000	0.65	296,000
Lane Change/Merge	0.2 million	192,000	0.20	39,000
Rear-End Crashes, Driver Warning	1.7 million	1,547,000	0.49	759,000

NHTSA
People Saving People

Benefits and Cost of Selected ITS Crash Countermeasures



* Calculated on the basis of Crashes Prevented by Roadway Departure, Rear-End, Lane Change and Merge Countermeasures

[1] Total cost is based upon 10 million vehicles per year with ITS countermeasures installed in the entire motor vehicle fleet

Federal Highway Administration ITS Research Program

ITS America Joint Committee Meeting
AVCS/Safety & Human Factors

August 5, 1997

San Diego, California

FHWA ITS Research Program

Major Program Components

- Automated Highway System
- Driver Vehicle Interface for ITS
- Motor Carriers (CVO)

FHWA - ITS Research Program

Automated Highway System

Background

- Largest Single Effort
- Government - Industry - Academia Collaboration
- Multi-Year Cooperative Agreement
- National Automated Highway System Consortium (NAHSC)
- Stakeholder Involvement

FHWA - ITS Research Program

AHS - Current Focus

- Demo '97
- Progressive Deployment
- Case Studies
- Stakeholder Involvement

FHWA - ITS Research Program

AHS - Current Focus

Case Studies

- Understand AHS Applications to Specific Transportation Needs
- Evaluate Concepts
- Engage Associate Participants at State and Local Level

Locations (some)

- Houston Metro (transit)
- IVTI Greater Yellowstone
- Virginia I-81
- So. Calif. ITS Priority Corridor

FHWA - ITS Research Program

AHS/IVI Linkage

- Capability Packages
  - Full range of vehicle control across all 4 platforms
- Cooperative Systems
  - Infrastructure - vehicle
  - Vehicle - vehicle
- Staged Deployment
  - Linkage between generations
- TRB Panel's Help

FHWA - ITS Research Program

Motor Carriers

- Recent Projects
- IVI Linkage

FHWA - ITS Research Program

OMC Recent Projects

- Drowsy Driver
- Brake Testing Devices
- Automated Roadside Inspection
- Commercial Vehicle Incident Recorder
- Smart Cards for CVO
- Advantage I-75

FHWA - ITS Research Program

OMC / IVI LINKAGE

- On Board Diagnostics
  - Driver
  - Vehicle
  - Cargo
- Benefits of Truck Safety Systems
- Integration Needs
- Early Winner

Enhanced DVI Program

Original DVI Program

- Coordination of FHWA and NHTSA Human Factors Programs

Enhanced DVI Program

- Addition of efforts to cover IVI vehicle requirements
- Inclusion of FTA and OMC
- Emphasis on integration of activities

DVI Human Factors Integration Effort

- Identify key human factors integration issues for Generation 1 IVIS/CAS systems
- Identify critical human factors knowledge gaps
- Design and develop prototype driver delivery system which consolidates driver information
- Conduct integration experiments/studies
- Consolidate integration guidelines with ATIS/CVO guideline document

Emphasis on assuring transition from one system to another is smooth and efficient

In-House Research Facilities

SIGNSIM	• Sign Simulation Lab • Programmable Stimulus Presentation
VIDSIM	• Part-Task Driving Simulator • In-Vehicle Display Evaluation
HYSIM	• Highway Driving Simulation Lab • Safety and ITS HF Research
Instrumented Vehicle	• Reconfigurable Dashboard • In-Vehicle Navigation Display

A Key Feature of the HFFRV

Picture

One of the key features of the Human Factors Field Research Vehicle is the reconfigurable dashboard. This enables researchers to study the integration of multiple display timing, information priority, display location, and information presentation.

INTELLIGENT VEHICLE INITIATIVE AND TRANSIT

An Opportunity to Aid Transit Operators and Travelers

Denis J. Symes
Federal Transit Administration
August 5, 1997
Intelligent Vehicle Initiative Forum
San Diego, CA

IVI AND TRANSIT

TRANSIT STATISTICS

U.S. TRANSIT BUS FLEET:

67,000 HEAVY-DUTY TRANSIT BUSES - 90 PASSENGERS EACH

28,000 PARA-TRANSIT VEHICLES - 8-29 PASSENGERS EACH

7.9 BILLION TRANSIT TRIPS IN 1995
- ABOUT 63% WERE BUS TRIPS.
- ABOUT 5% OF ALL COMMUTERS USE TRANSIT;
  - IN URBAN AREAS, THIS IS ABOUT 20-75%.

IVI AND TRANSIT

ITS AND TRANSIT

ADVANCED PUBLIC TRANSPORTATION SYSTEMS PROGRAM - THE TRANSIT COMPONENT OF ITS

APTS - ADVANCED COMMUNICATION, COMPUTER, NAVIGATION AND INFORMATION TECHNOLOGIES

- FLEET MANAGEMENT SYSTEMS
- AUTOMATIC PASSENGER COUNTERS
- ELECTRONIC FARE COLLECTION SYSTEMS
- PASSENGER INFORMATION SYSTEMS

THERE ARE OVER 269 APTS SYSTEMS CURRENTLY DEPLOYED IN THE U. S.

IVI AND TRANSIT

<u>IVI FOCUS</u> - GIVE DRIVERS IMPROVED WARNING, CONTROL AND INFORMATION.

CAPABILITY PRINCIPALLY VEHICLE BASED

WILL PRESENT DRIVERS AND BUS OPERATORS WITH WARNING AND CONTROL INFORMATION FOR SAFETY AND EFFICIENCY

<u>TRANSIT FOCUS</u> - INCLUDES OPERATOR AND PASSENGER

TRANSIT PROVIDES SAFE, EFFICIENT AND, RELIABLE TRANSPORTATION. IVI WILL MAKE SIGNIFICANT INROADS TO MEETING THESE OBJECTIVES.

IVI AND TRANSIT

KEY FEATURES OF THE IVI AND FTA'S VIEW OF THE INTELLIGENT BUS

INTELLIGENT VEHICLE INITIATIVE

ASSISTANCE IN OPERATING VEHICLE:

FOCUS ON:

- WARNING, INFORMATION AND CONTROL
- DRIVER MONITORING
- PRECISE DOCKING
- LANE KEEPING
- MAINTENANCE OPERATIONS
- PEDESTRIAN SENSING
- ADAPTIVE CRUISE CONTROL
- PRECISE MANEUVERING IN TERMINALS
- CREEP CONTROL
- LOW FRICTION CONTROL
- COLLISION AVOIDANCE

INTELLIGENT BUS

SYSTEMS AND TECHNOLOGIES:

FOCUS ON:

- COMMUNICATION SYSTEMS
- FLEET MANAGEMENT / SCHEDULING
- ELECTRONIC FARE PAYMENT
- REAL-TIME PASSENGER INFO.
- CUSTOMER INFORMATION
- NAVIGATION
- ELECTRONIC POWER / BRAKING MGT.
- IVI SYSTEMS

IVI AND TRANSIT

<u>IVI PROGRAM FOCUS</u> - VEHICLE - NOT INFRASTRUCTURE - BASED.

TRANSIT SYSTEMS - CURRENTLY EQUIPPED WITH MOBILE COMMUNICATION SYSTEMS, CENTRALIZED COMPUTERS AND DISPATCH CENTERS.

COMBINING THESE CAPABILITIES WITH TRANSIT IVI SYSTEMS WILL ENHANCE SAFETY, EFFICIENCY, AND SERVICE.

IVI AND TRANSIT

<u>FTA IVI INTEREST</u>

FTA DEVELOPING IVI TECHNOLOGIES TO ENHANCE PASSENGER (AND OPERATOR) SAFETY, SYSTEM EFFECTIVENESS, EFFICIENCY, AND SERVICE TO THE PUBLIC.

SERVICE BENEFIT AND APPLICATION / DESCRIPTION
<u>PASSENGER AND OPERATOR SAFETY</u>
<u>SYSTEM EFFECTIVENESS AND EFFICIENCY</u>
<u>IMPROVED PUBLIC SERVICE</u>

IVI AND TRANSIT

SERVICE BENEFIT AND APPLICATION / DESCRIPTION

TRANSIT SAFETY STATISTICS

CATEGORY (NUMBER OF:)	NUMBER	REFERENCE
INCIDENTS EXCEEDING $1,000 VALUE	49,593	P. 33
FATALITIES	88	P. 34
INJURIES	42,232	P.35
COLLISIONS	24,373	P. 36
BUSSES GOING OFF ROAD	93	P.37
PERSONAL CASUALTIES 1/	19,175	P. 38
FIRES	298	P. 39

1/ includes "Inside Vehicle, Entering/Exiting Vehicle, In Stations/Bus Stops, Parking Facilities, and Right of Way)

NOTE: These statistics must be considered in light of the 7.9 billion passenger trips pervaded by transit.

| SOURCE: Safety Management Information Statistics, 1995 Annual Report, Federal Transit Administration

IVI AND TRANSIT

PASSENGER AND OPERATOR SAFETY

THE BUS OPERATOR - INFORMED OF IMMEDIATE ACCIDENT THREAT:

- **OTHER MOTOR VEHICLES**
- **TRAINS - GRADE CROSSINGS - (USING TRANSIT COMMUNICATIONS SYSTEM)**

PASSENGER INJURIES

- **PASSENGERS BEING THROWN OR SHAKEN IN A COLLISION**
- **PASSENGERS FALLING UNDER WHEELS OF THE BUS, ESPECIALLY REAR WHEELS.**

IVI SENSORS MOUNTED ON THE BUS CAN BE INSTALLED TO DETECT POTENTIAL INCIDENT AND ALERT THE OPERATOR.

IVI SYSTEMS WILL ENHANCE SAFETY BY MONITORING OPERATOR AND DRIVER ACTIONS.
DROWSY OR IMPAIRED OPERATORS WILL BE QUICKLY IDENTIFIED SO THEY CAN BE RELIEVED.

IVI AND TRANSIT

<u>SYSTEM EFFECTIVENESS AND EFFICIENCY</u>

PRECISE DOCKING AND CURB ALIGNMENT FOR EASIER AND SAFER PASSENGER ENTERING OR EGRESS

AUTOMATIC VEHICLE GUIDANCE - PRECISE MANEUVERING IN TERMINALS OR AUTOMATICALLY IN MAINTENANCE YARDS.

MIXED TRAFFIC TRANSIT OPERATIONS - ADAPTIVE CRUISE CONTROL REQUIRED SO BUSES CAN SAFELY PLATOON .

INTELLIGENT LOW-FRICTION CONTROL SYSTEM PERMITS LOW FRICTION CONDITION TO BE IDENTIFIED

IVI AND TRANSIT

IMPROVED PUBLIC SERVICE

ROUTING / NAVIGATION INFORMATION TO HELP DEMAND RESPONSIVE DRIVERS FIND PICK-UP POINT OR DESTINATION.

SIGHT IMPAIRED PEOPLE - GPS DIRECTS PERSON TO PRECISE BUS STOP LOCATION.

- IVI PERMITS PRECISE DOCKING SO THE PASSENGER CAN READILY AND SAFELY BOARD BUS.
- BUS PRECISELY ALIGNED FOR FRONT AND REAR DOORS CLOSE TO THE CURB - PASSENGER CAN SAFELY AND CONVENIENTLY ENTER.

ITS America

INTELLIGENT TRANSPORTATION SOCIETY OF AMERICA

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